Compressed Air Magazine

AUGUST 1960

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TONS OF LIQUID HYDROGEN
PROJECT ROVER
SANTA FE RELOCATES
DEATH VALLEY SAGA
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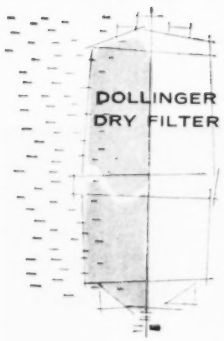

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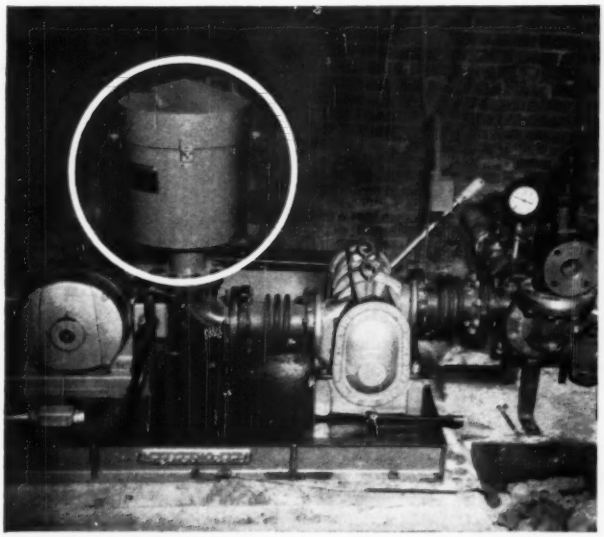

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on the cover

A strictly utilitarian mass of pipes, vessels and machinery rises above the marshy pine flats near West Palm Beach, Fla. Its product—liquid hydrogen in tonnage quantities. Shown is the Air Force's Apix plant. Our lead article this month, *Making the Ultimate Fuel*, another story, *Project Rover—A Look at Jackass Flats*, and the editorial, *Kryos*, deal with liquefied gases and the cold, but engrossing world of cryogenics.

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A morass of gas handling equipment—compressors, expanders, reactors, exchangers and vacuum pumps—make up the Apix plant where tons of liquid hydrogen are turned out.

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A 44-mile-long stretch of new right-of-way is being built for the Santa Fe Railroad through rugged country in Arizona. Crawler drills and portable compressors are hard at work.

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One of the West's historians spells out some interesting facts about Death Valley and the annual trek made by many to the cruel but beautiful locale.

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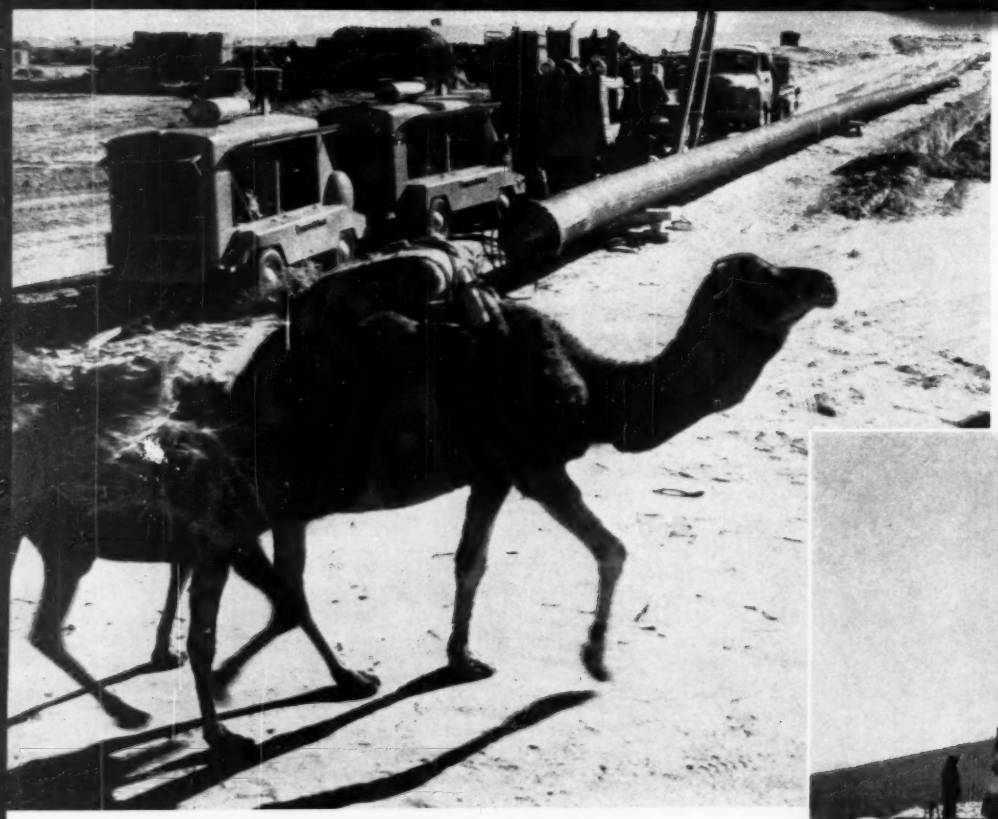
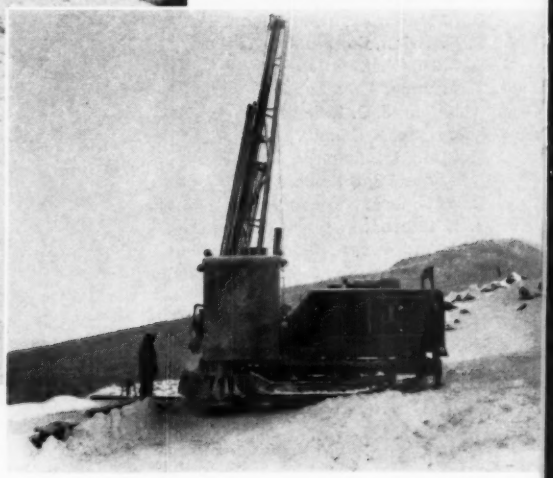


Two 600-cfm Gyro-Flo portables on a pipe line construction job in the Sahara Desert.

A 600-cfm Gyro-Flo on an Ingersoll-Rand Drillmaster rig, operating in sub-zero temperatures on a quarry job.



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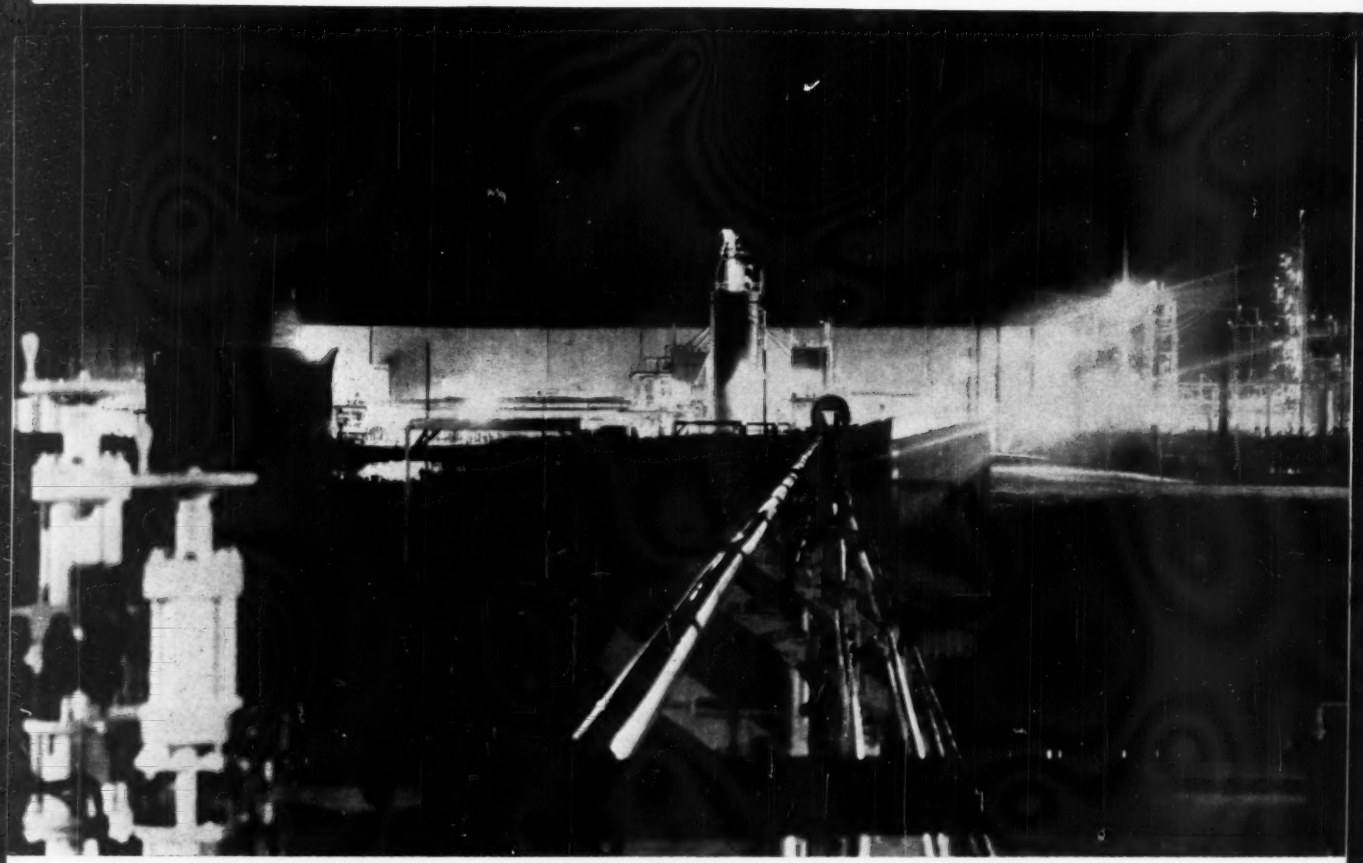


A strictly utilitarian mass of pipes, vessels and machinery rises above the marshy pine flats near West Palm Beach, Fla. Its product—liquid hydrogen in tonnage quantities.

Making the "Ultimate" Fuel

R. J. Nemmers

HYDROGEN has long been an element of considerable interest to chemists because it's a basic building block of organic chemistry. Hydrogenation processes for everything from gasoline to margarine make use of it. Its presence is vital in many important compounds, including, of course, water. As an uncombined element however it hasn't, until now, been of much use. Certain heat treating methods have used a lot of it. Balloons are sometimes inflated with it, but helium is safer.

Today, hydrogen is getting considerable attention as a fuel, specifically a fuel of the space age. The light element, when reacted with oxygen or fluorine, is rated the most effective rocket propellant yet devised. Furthermore, teamed with nuclear power, it is considered to be the fuel of the future. More specifically speaking, liquid hydrogen is the substance wanted. The gas-to-liquid ratio of H_2 is 849:1, thus, from a practical standpoint, the most efficient way to carry it about is in the liquid state.

All of this interest in liquid hydrogen comes at a time when there is equally as much interest in solid rocket fuels. The latter are needed for military purposes where constant readiness is a must. Liquid hydrogen can be used, however, for space vehicles where additional time can be spent in fueling and making ready the flight.

Specific Impulse

One of the reasons that hydrogen is the most effective chemical rocket fuel is that it is highly reactive—as every high school chemistry student knows, it is explosively reactive under certain conditions. But so are many other substances. The other part of the interest in hydrogen lies in the light weight of its combustion product. A gallon of liquid hydrogen weighs but 0.593 pound.

All of the considerations of power and weight are taken into account by something known to rocketeers as specific impulse. Expressed in seconds, the units of specific impulse (I_{sp}) are pounds of thrust per pound per second of propellant. The following example indicates the way I_{sp} values have meaning (for such values are only relative). Assume two fluids when reacted with oxygen have the same thrust or energy per gallon, but fuel "H" weighs less than half as much as fuel "K," thus the resulting weight of the propelling gas is less for "H." "H" then, has the higher I_{sp} value —the thrust thereby derived can lift and accelerate considerably more payload because less of it is expended carrying the rest of the fuel required for continuing lift and acceleration. Putting it simply, it's got more energy per pound ("more wham per gram," says one scientist).

Some examples of chemical fuel I_{sp} values compared on identical bases show

that nydrogen-fluorine mixtures top the list at 365 seconds. Next in line are LOX-H_2 mixtures (liquid oxygen and hydrogen) at 350 seconds. LOX-kerosene has a value of 260. In the 240–250 range come many of the solid fuels, with more advanced ones expected to produce about 265 to 275 seconds.

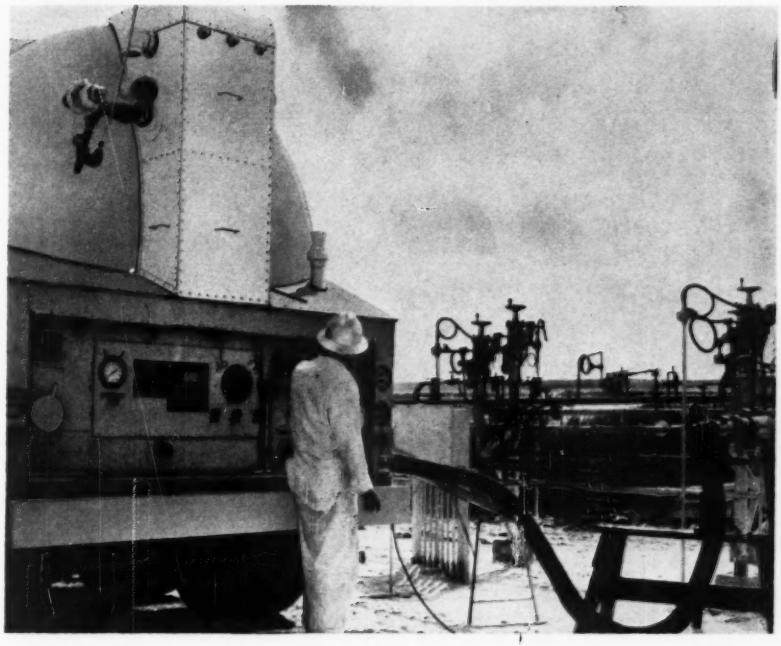
The differences in payload possible with only small increases in I_{sp} value are remarkable. In the case of Pioneer V, now in orbit around the sun, the tiny 95-pound man-made planet could have weighed 2500 pounds had all three of its three stages been fueled with LOX-H_2. The Pioneer V rockets were fueled with LOX-kerosene and the I_{sp} value difference, as indicated. was only about 90 seconds.

Hydrogen teamed with nuclear reactors, however, presents an even more promising outlook to rocketeers. In a simple nuclear rocket, liquid hydrogen is heated rapidly in the hot core of a reactor, expanding to the gaseous state and discharging at high speeds into the vacuum of outer space. The estimated I_{sp} value of such an arrangement is about 800, far above even H_2-F_2 figures. With such a space drive as this, interplanetary travel is more than practical. Feasibility studies are even now under way (see page 13).

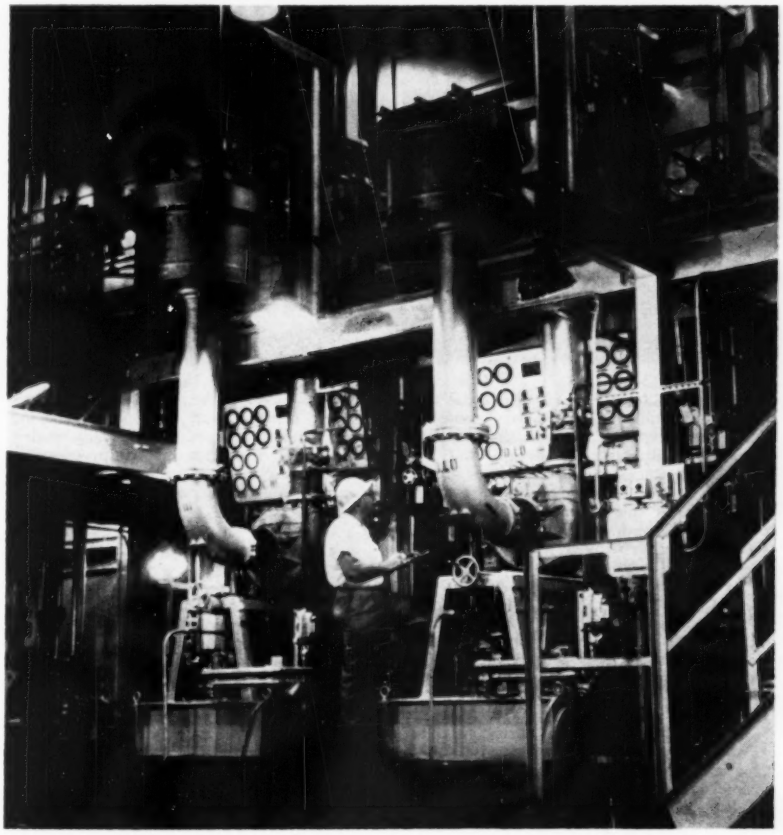
Obtaining Hydrogen

The various means of obtaining hydrogen are actually quite few. The most familiar, of course, is by the electrolysis of water—a typical school experiment. The reaction of iron and zinc with sulphuric or hydrochloric acids also gives off a hydrogen stream, albeit usually quite impure. When steam is passed over heated carbon, the water dissociates and molecular hydrogen is derived as the oxygen content of water combines with the carbon. H_2 can also be derived by dissociating it from such hydrocarbons as crude oil, natural gas, etc. Almost none of the other means of isolating hydrogen are commercially practicable, certainly not for the tonnage requirements of the space age.

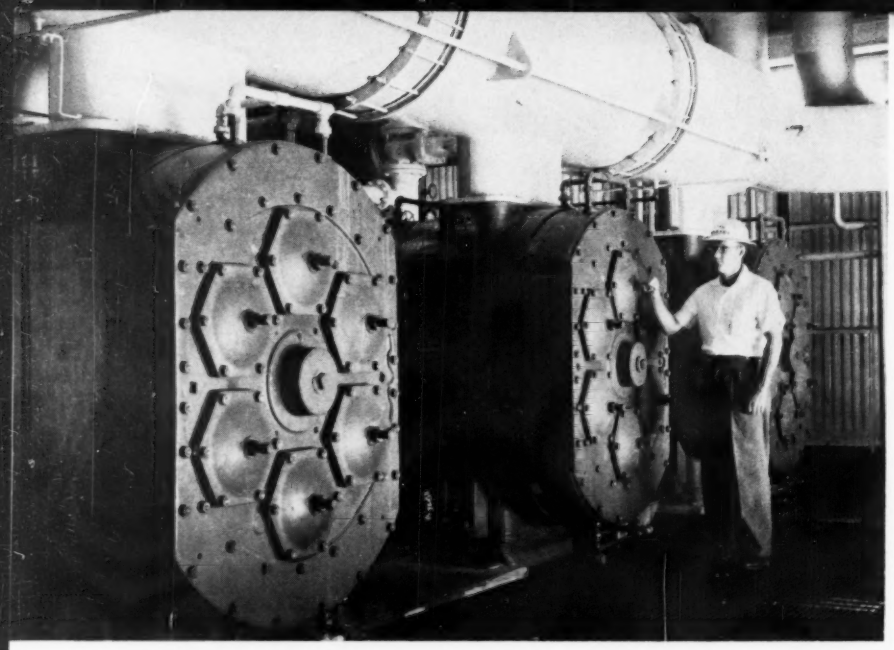
A variation of the crude oil separation and steam-carbon processes is utilized to obtain hydrogen at the free world's first tonnage liquid-hydrogen-producing plant at Apix, Fla. This plant starts with crude oil and, by means of the Texaco partial oxidation process, derives a hydrogen stream made up not only of the approximately one-sixth (weight fraction) of the crude that is hydrogen, but also of the not inconsiderable quantity of the gas available from steam dissociation. This method of deriving hydrogen from crude oil has achieved great recognition in only the last five years and is used to provide hydrogen for ammonia nitrogen-fixation plants as well.

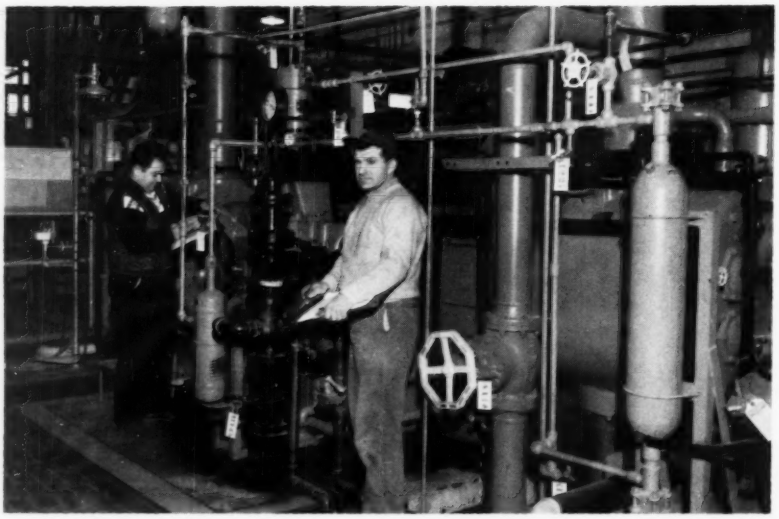


FILL 'ER UP With slightly more complicated connections than the average gasoline tanker, this Air Products over-the-road liquid hydrogen trailer is shown being filled.



EXPANDERS The energy given up by the expanding gases in providing refrigeration for the liquefaction plant is dissipated by air blowers, shown here with their intakes. The Air Products-designed hydrogen expanders are the first of their type in existence and operate at high speeds to pass high nitrogen and oxygen throughputs.





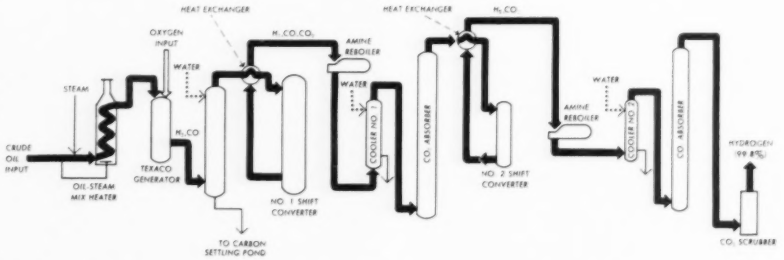
COMPRESSORS Handling the high-volume gas flows in the Apix plant is a job for a number of heavy-duty compressors. Their capacity and horsepower are, of course, secret. It can be said, however, that the machines are of a horizontal, multi-cylinder, direct-driven design that lends itself to the simultaneous compression in multiple stages of more than one gas. There is even use made of vacuum cylinders at Apix on the same compressor frames with compression cylinders. In the picture at the top is shown the cylinders of an Ingersoll-Rand HHE compressor that takes the hydrogen product stream from the partial oxidation unit and boosts it to 600 psig prior to purification. The other picture shows a similar machine in use at the Painesville, Ohio, prototype plant. The schematic flow sheet shows the location of compressors in the Apix facility as far as applications are concerned but does not necessarily show the number of machines in use. The majority of compressors are reciprocating units, however there are some rotary positive displacement Axi-compressors in use handling large volumes of nitrogen at comparatively low pressures. In addition, because many of the plant's instruments and valves are air controlled or operated, an I-R ESH-1 nonlubricated 2-stage compressor furnishes air to this equipment at 110 psig. A duplicate unit furnishes air for general plant use.

The very existence of United States Air Force Plant No. 74 has only recently been declassified. Its capacity and all things pertaining thereto have not been released. What can be said about the plant is that it produces tonnage quantities of hydrogen at an annual rate of several millions of pounds, one estimate being 10,000,000 pounds per year. By a whim of those who code name such projects, Plant 74 is known as "Papa Bear."

Although owned by the Air Force, the plant was designed, built and is now operated by Air Products, Inc. The story of the crash design and construction of Papa Bear is something of a saga in itself. Much of the plant's design was based on a smaller Air Products-designed-and-built plant at Painesville, Ohio. One of the interesting points is that construction of Papa Bear started before the smaller facility was even operating. Changes indicated as a result of operation at the prototype plant were incorporated into the design as construction progressed.

Generally speaking, the major problems connected with the design of the Apix plant had to do with size. Many of the theories of how best to liquefy hydrogen—and keep it that way—were pretty well worked out and tested on a laboratory scale. (Part of this background will be discussed a little later.) Going from the lab to a tonnage plant, however, is no easy task and is usually done first with pilot plants, then an interim plant or plants in which the problems involved in pushing capacities upward are solved. Only then are large scale producers designed.

One such size problem that might have reduced Papa Bear's capacity to about 20 percent of what it now is, has to do with the refrigeration expanders. In these, a gas stream is chilled by making it do work, thereby giving up energy. In addition, by the expansion of the gas through the significant part of the Mollier curve, added refrigeration is derived. None of the available reciprocating or centrifugal expanders



SCHEMATIC FLOWSHEETS Hydrogen produced in the partial oxidation plant (shown schematically above) is delivered to the purification, conversion and liquefaction systems shown on the next page. The solid black line traces the hydrogen product stream from beginning to end. The lightest lines show hydrogen recycle streams; the mid-weight lines trace the nitrogen coolant and heat exchange streams.

could possibly handle the high hydrogen and nitrogen throughputs desired at Apix. Air Products began designing a suitable expander that would handle the large capacities desired. The one finally adopted stems from a re-evaluation of basic hydrogen thermodynamics and involves ultra-high-speed turbo-type machines.

Raw Materials

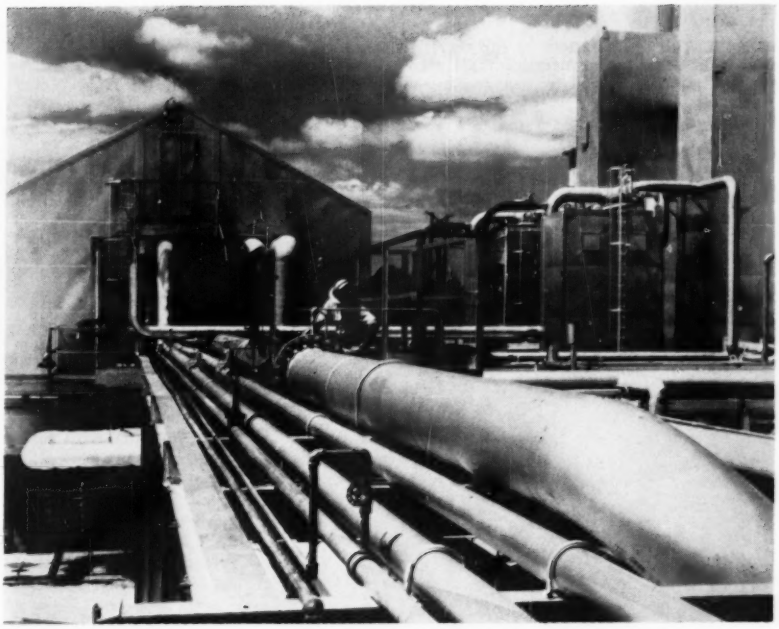
Air, crude oil and water plus electrical energy are the raw materials of the Apix plant. The basic partial oxidation process calls for the burning of oil with oxygen. The oxygen is produced as a liquid in an air fractionation plant, and supplied as a gas. It is vaporized prior to delivery by a counterflowing stream of incoming air. Liquefied nitrogen is also produced and is used in another heat exchanger extracting heat in the hydrogen liquefaction cycle far down the line. Nitrogen is used as an intermediary heat transfer agent because of the dangers of bringing oxygen into close contact with hydrogen.

The partial oxidation of the crude oil produces an effluent gas stream of which about 46 percent (volume) is hydrogen and 47 percent is carbon monoxide. The hot stream flows to a 2-stage carbon monoxide shift converter in which steam and carbon monoxide are reacted in the presence of a catalyst to form H_2 and carbon dioxide. Carbonate absorbers between stages and following the converters remove the carbon dioxide.

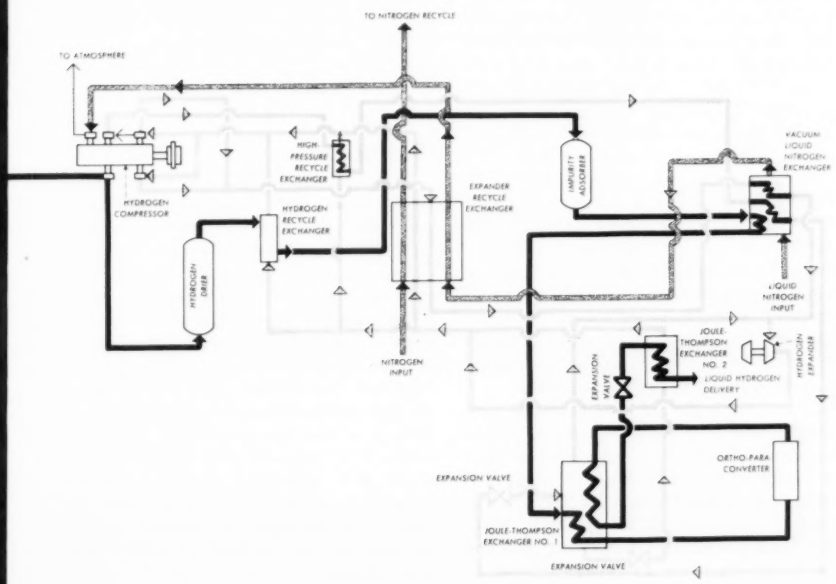
Purification

The final effluent of the hydrogen-making section is delivered at a pressure of 325 psig and is 98.8 percent pure; the contaminants are methane, nitrogen, argon, carbon monoxide and carbon dioxide. In addition, the stream is saturated with water vapor. The product gas is compressed to 600 psig and passed through a silica gel dryer at 40° F to remove the water vapor. Then the stream is cooled by a counterflow stream of low-pressure hydrogen at about −300° F. Methane is adsorbed on activated charcoal at −270° F. In a vacuum liquid-nitrogen heat exchanger the stream is further cooled to −315° F at which point the remaining CO, N_2 and A can be adsorbed on silica gel. The resultant stream is termed five 9's pure —in other words, 99.999-percent pure. Actually its purity is somewhat better than that—probably six to seven 9's—although, because analysis equipment is inaccurate at those levels, there is no way of telling for sure.

Purity of the hydrogen stream is important because, at the supercooled temperatures at which the liquid hydrogen is handled, all other contaminants except helium freeze solid, thereby interfering with proper valve action and plugging orifices and ports.



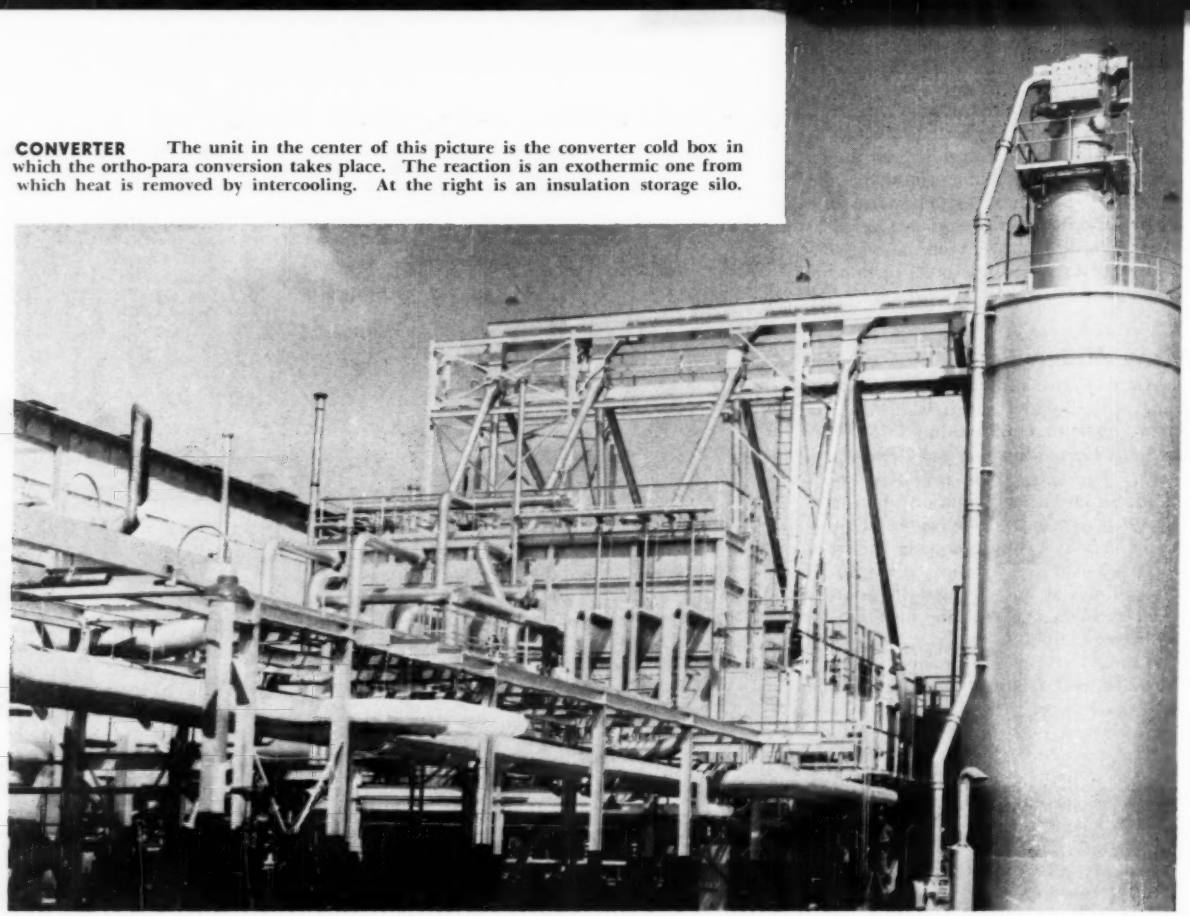
AIR PLANTS **In the background are the cold boxes of the pair of air separation plants that provide oxygen for the partial oxidation crude plant, and nitrogen for heat transfer and cooling purposes in the hydrogen liquefaction system. The "negative" Btu's at this cryogenic plant are conserved in much the same way, and by use of similar equipment, as "positive" Btu's are saved and used in thermal power plants.**



Ortho To Para

In the years when cryogenics got its start, hydrogen was always an anomaly among the liquid gases. It evaporated much faster than apparent heat leakage into its containers could explain. Finally it was discovered that the heat was coming from within the hydrogen itself!

There are two basic forms of molecular hydrogen. (These two forms should not be confused with different isotopes of hydrogen—a property existing on the atomic rather than molecular scale.) There is *ortho*hydrogen and *para*hydrogen. As will be remembered from school-day chemistry, hydrogen atoms have a single electron spinning around the atomic nucleus. Further, molecular hydrogen is made up of two atoms of hydrogen (H_2). In the *ortho* form of



CONVERTER The unit in the center of this picture is the converter cold box in which the ortho-para conversion takes place. The reaction is an exothermic one from which heat is removed by intercooling. At the right is an insulation storage silo.

molecular hydrogen both electrons making the rounds of the hydrogen protons spin in the same direction. In the *para* form, the spins are opposed, that is, one may circle clockwise, the other counterclockwise. The *para* form is the equilibrium state of liquid hydrogen. Gaseous hydrogen, on the other hand, is customarily in the *ortho* form. Thus, when hydrogen is liquefied, a slow conversion of the *ortho* type to *para* begins. The reaction is exothermic, and although the amount of heat evolved (heat of conversion) is not large, it is greater than the heat of evaporation (latent heat) and thus will cause a serious loss of hydrogen by evaporation.

In the early 1950's the Cryogenics Laboratory of the National Bureau of Standards, Boulder, Colo., discovered and began development of a catalytic means of converting *ortho*hydrogen to the *para* form prior to liquefaction. This work was explained in an article in *Compressed Air Magazine*, December 1953. Today, the results of this experimentation show up in the catalytic converters at Apix in which the hydrogen product stream is converted to the *para* form just prior to liquefaction. The catalyst is chromium oxide, and although the technique had been well researched at NBS, never had such a large scale unit been built. Air Products took a number of calculated risks in scaling up the plant because of the crash nature of the program, however few unforeseen difficulties were encountered. The converter is a multistage one with intercooling to remove the heat of reaction.

In final stages of production the chilling of the hydrogen stream from the −315° F, at which it leaves the purification section, to the liquefaction temperature of −423° F is accomplished (as shown on the accompanying flow sheet) by several heat exchangers, Joule-Thompson expansion valves and turbo expanders. As a part of this cycle, the gas flows through the intercooled *ortho-para* converter. Finally, the gas condenses as a colorless liquid at a temperature of −423° F and pressure of 16 to 20 psia.

Handling

At one time it was believed that handling and transporting liquid hydrogen might be the toughest of all problems in making it by the ton. Actually, according to Air Products engineers, the techniques are only a little more difficult to apply than those required for transporting liquefied petroleum gases.

There are some unique problems, however. Liquid hydrogen, for example, cannot be exposed to air. The air over its surface will first liquefy and then freeze, with solid dense oxygen crystals sinking to the bottom of the flask. With two such potentially dangerous (in combination) elements so closely mixed, an energy input of a very low level is sufficient to initiate an explosion. Yet, with several years of operating experience behind Papa Bear, there have been no serious accidents in the daily handling and transport of the fluid. Indeed, the safety record already established is enviable. There are some properties of liquid hydrogen that make it safer to use even than gasoline. Small leaks, for example, aren't as dangerous because the liquid hydrogen dissipates rapidly rather than accumulating in puddles, soaking the ground or insulation, or flowing into hazardous areas.

Outlook

Although the output of the Apix Papa Bear plant is, of course, earmarked for governmental space use, scientists speculate that there will be a growing field of uses for liquid hydrogen as fuel. Most of these theories have evolved just since it was found that hydrogen could be handled safely with the application of certain rules and the installation of the required equipment. Its use in commercial rocket-powered aircraft, some feel, is a distinct possibility. Furthermore, it is believed that nuclear power could well make the derivation of hydrogen from water so cheap that the fuel could be used in railroad engines or even in over-the-road or off-the-highway vehicles.

The preceding article "Making the 'Ultimate' Fuel" details the why's of the use of hydrogen in rockets and missiles and tells as much as security allows of the processes by which liquid hydrogen is produced in tonnage lots. For a glimpse of how hydrogen will be used in the United States missile and space program, the following article takes you to the test site of the Atomic Energy Commission's nuclear rocket project.

project rover

A Look at Jackass Flats

TWO important scientific fields—nuclear energy and cryogenics—will be put to work on an advanced nuclear reactor for rocket propulsion when static tests take place next year. Construction has begun on Test Cell "C" at Jackass Flats, Nev., by the engineering prime contractor for the U. S. Atomic Energy Commission—Air Products, Inc. In this cell, the reactor will be operated in conjunction with liquid hydrogen at a temperature of —423° F, thus paving the way for eventual flight tests. Last summer successful tests were conducted with the KIWI-A reactor and this summer two reactors will be tested in the KIWI-A prime series. The next phase, using the liquid hydrogen, is scheduled for testing next year. A nuclear rocket will be propelled by the rapid vaporization of liquid hydrogen by the heat of the reactor and is expected to have spectacular performance characteristics. (See page 8, *Specific Impulse.*)

The technology gained by Air Products Inc. in the production and handling of liquid hydrogen at the Florida Apix facility is being applied by the company in the design and construction of this Nevada test facility. The line drawings on this and the following page show something of that design.

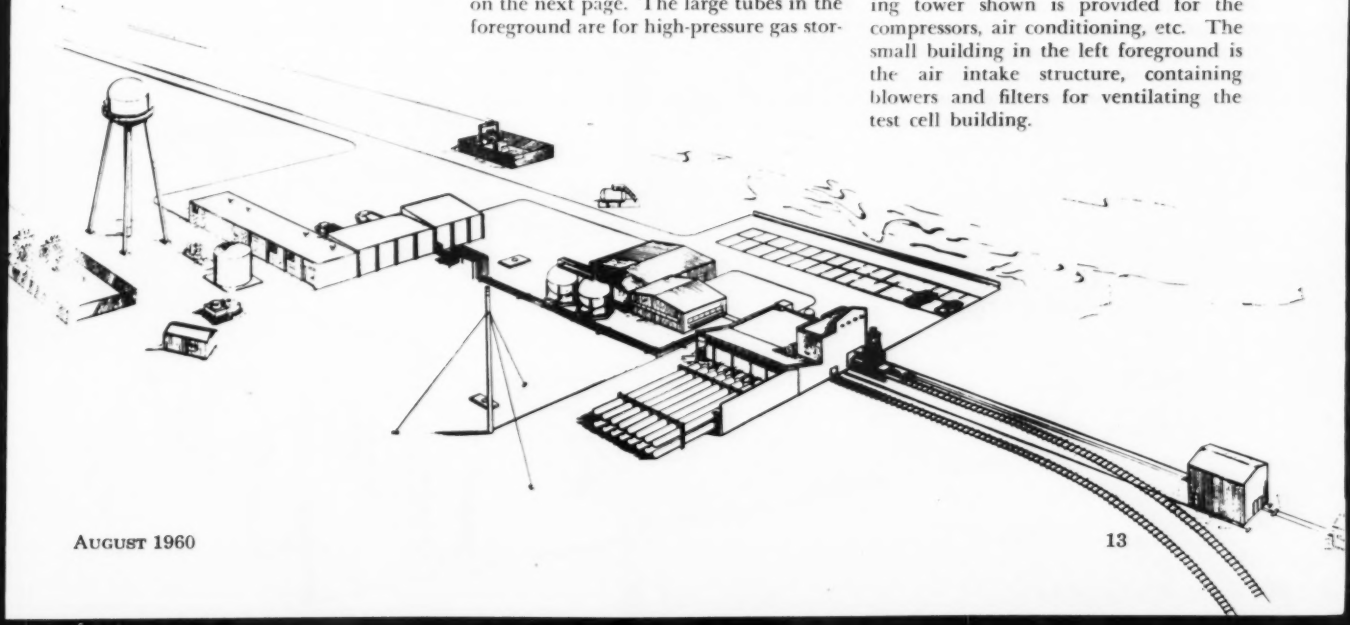
The Site

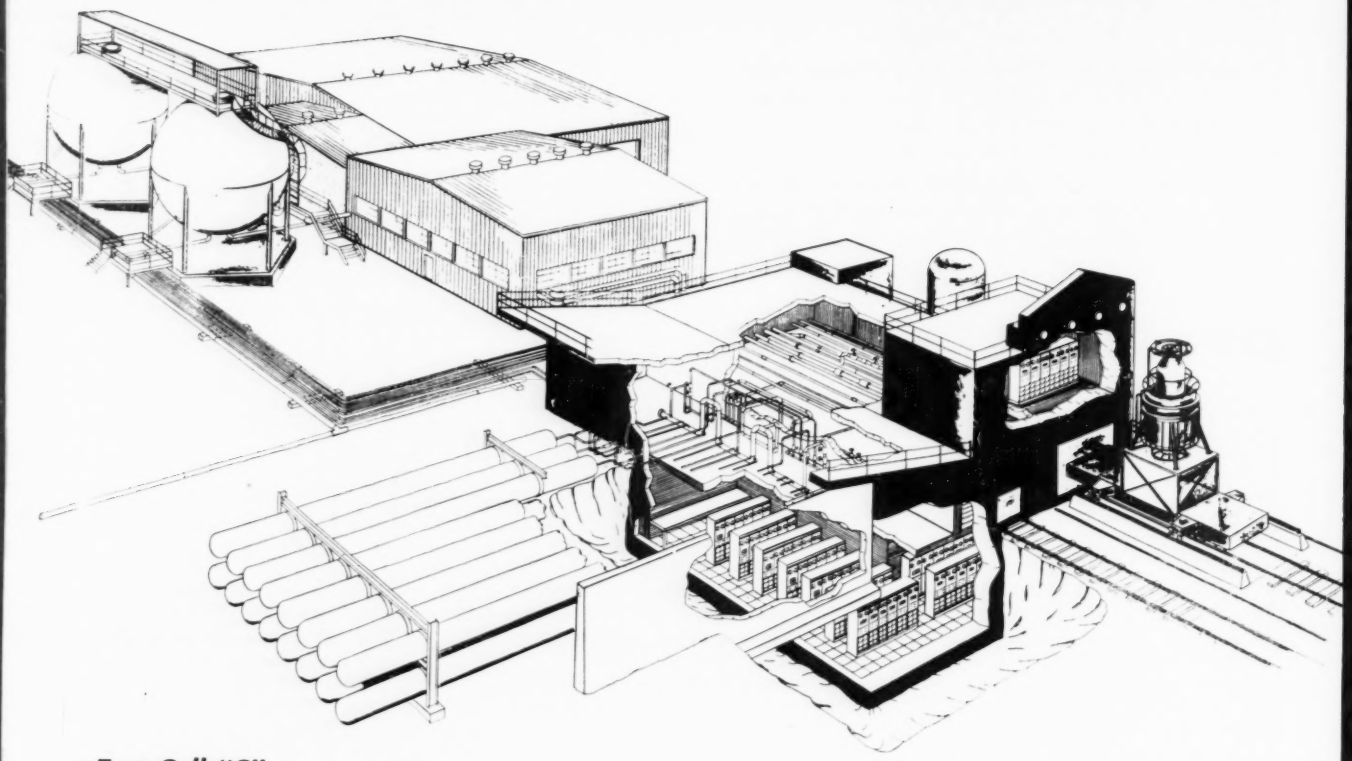
An over-all view of the testing site is sketched below. The nuclear reactor is railroad-cart-mounted, and pushed into position at the face of the test cell by a radio-operated electric locomotive. (The other terminal is a disassembly building several miles away.) The large structure in the lower right corner of the drawing is a moveable shed that can be positioned over the reactor during repair, maintenance or adjustment of the reactor and cart.

The main test cell building contains flow control and gas manifolding rooms and provides instrumentation, electronic gear and utilities for the area. Greater detail can be seen in the upper sketch on the next page. The large tubes in the foreground are for high-pressure gas storage. Immediately behind the test cell and adjacent to the spherical dewars are the cryogenic component testing building and the high-pressure, high-capacity pump and drive building.

The L-shaped structure in the background (detailed at the bottom of the next page) is the fill station which is utilized to support the Test Cell "C" complex. It includes a maintenance area, water pumps, electrical and electronic gear, gas compressors, and a liquid hydrogen pump and vaporizer. The electrical substation in the background furnishes power to operate the high-capacity liquid hydrogen pump. Near this substation is a propane tank for the operation of the flare stack, located in the foreground.

The substation on the left hand side of the drawing furnishes power for the entire facility. Of the two 150,000-gallon water tanks, one is a high tank for emergency and general use; the other, for reactor cooling water. The water-treatment installation is located between these storage tanks, and the cooling tower shown is provided for the compressors, air conditioning, etc. The small building in the left foreground is the air intake structure, containing blowers and filters for ventilating the test cell building.





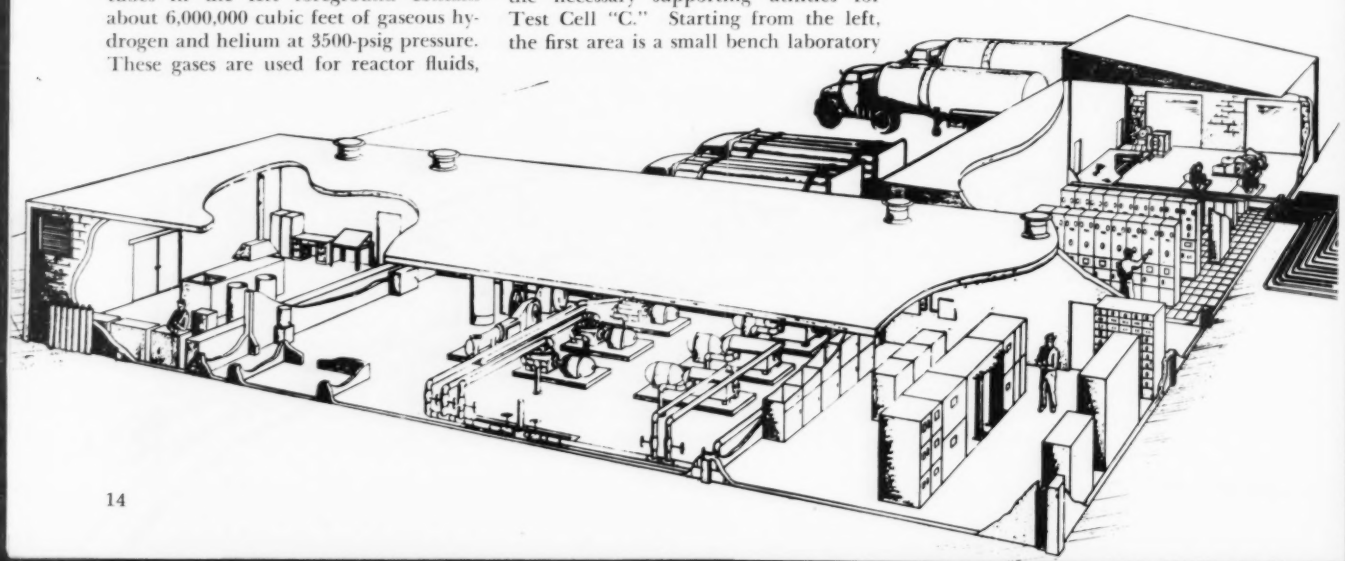
Test Cell "C"

In the foreground is the test cell proper (above)—a 2-story concrete structure with a penthouse. Located in the basement are the electronics room for instrumentation and telemetering of signals to a remote control position, and the machinery room for such supporting equipment as vacuum and hydraulic pumps and air conditioning units. On the first floor are the high-pressure gas manifolding room and the flow control room. These areas are used to distribute and regulate the various fluids in the test cell complex. Also located on the first floor are the hook-up room for connecting the reactor to the piping, and the effects room for measuring radiation properties. The penthouse contains additional experimental rooms.

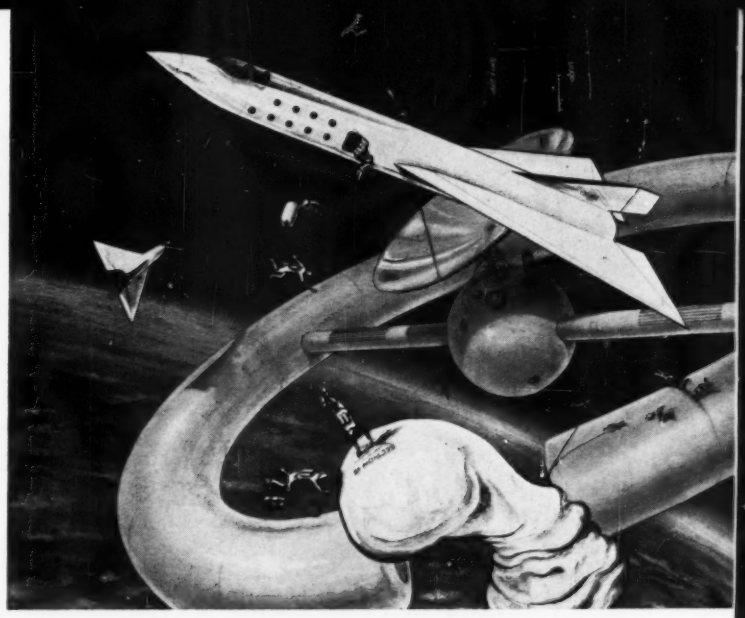
The sixteen high-pressure gas storage tubes in the left foreground contain about 6,000,000 cubic feet of gaseous hydrogen and helium at 3500-psig pressure. These gases are used for reactor fluids, dewar pressurization, and purging. The first building behind the test cell is the cryogenic fluid test facility, which is to be used for the testing of cryogenic components. The small building behind the test facility is used to house a high-pressure, high-capacity liquid hydrogen centrifugal pump and the large building houses its electric drive. This furnishes liquid hydrogen for both the test facility and the test cell. There will be an alternate gas-turbine drive for the pump. The dewars on the left of the sketch each contain 50,000 gallons of liquid hydrogen in a powder-vacuum insulated vessel.

Fill Station

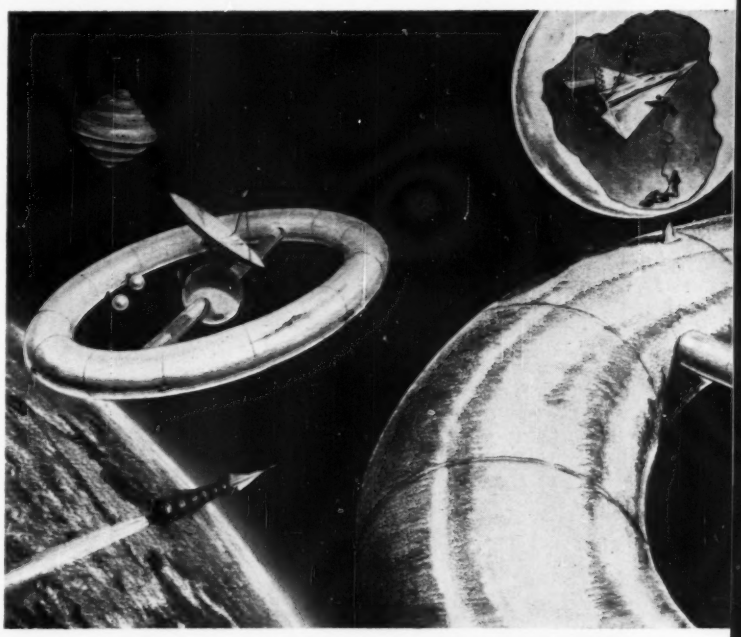
The fill station (below) is the site of the necessary supporting utilities for Test Cell "C." Starting from the left, the first area is a small bench laboratory for miscellaneous purposes. The next room is used for maintenance and provides space for the instrument air compressor and water pumps for cooling both the reactor cart and the reactor nozzle. The area in the near corner of the building is the electrical switchgear room and motor control center. The area immediately behind the electrical room is the control point in the fill station. It is used for the control of all local operations that do not need to be carried to the main control point several miles away, such as operations of the fill station and the cryogenic test facility. The area in the rear at the right side contains vacuum pumps, high-pressure gas compressors and the high-pressure liquid pump and vaporizer package. These are all used to transfer fluids.



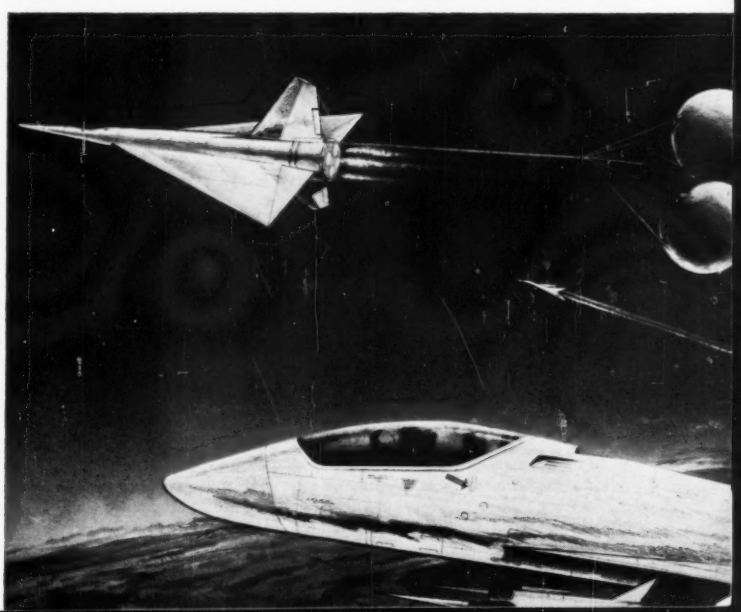
AIR IN SPACE



GOING UP Man's first inhabited space station may look like this. Made of a Goodyear Aircraft Corporation fabric, the structure could be packed in a tiny capsule (left center) for haulage into orbit. The sections would then be inflated with compressed air or a breathable mixture of oxygen and nitrogen or helium and joined together. Although the air would provide the needed stiffness, the bags could be made more rigid and permanent by filling an annular space between inner and outer linings with a foamed-in-place plastic. The fabrics are made either of organic or metallic fibers.

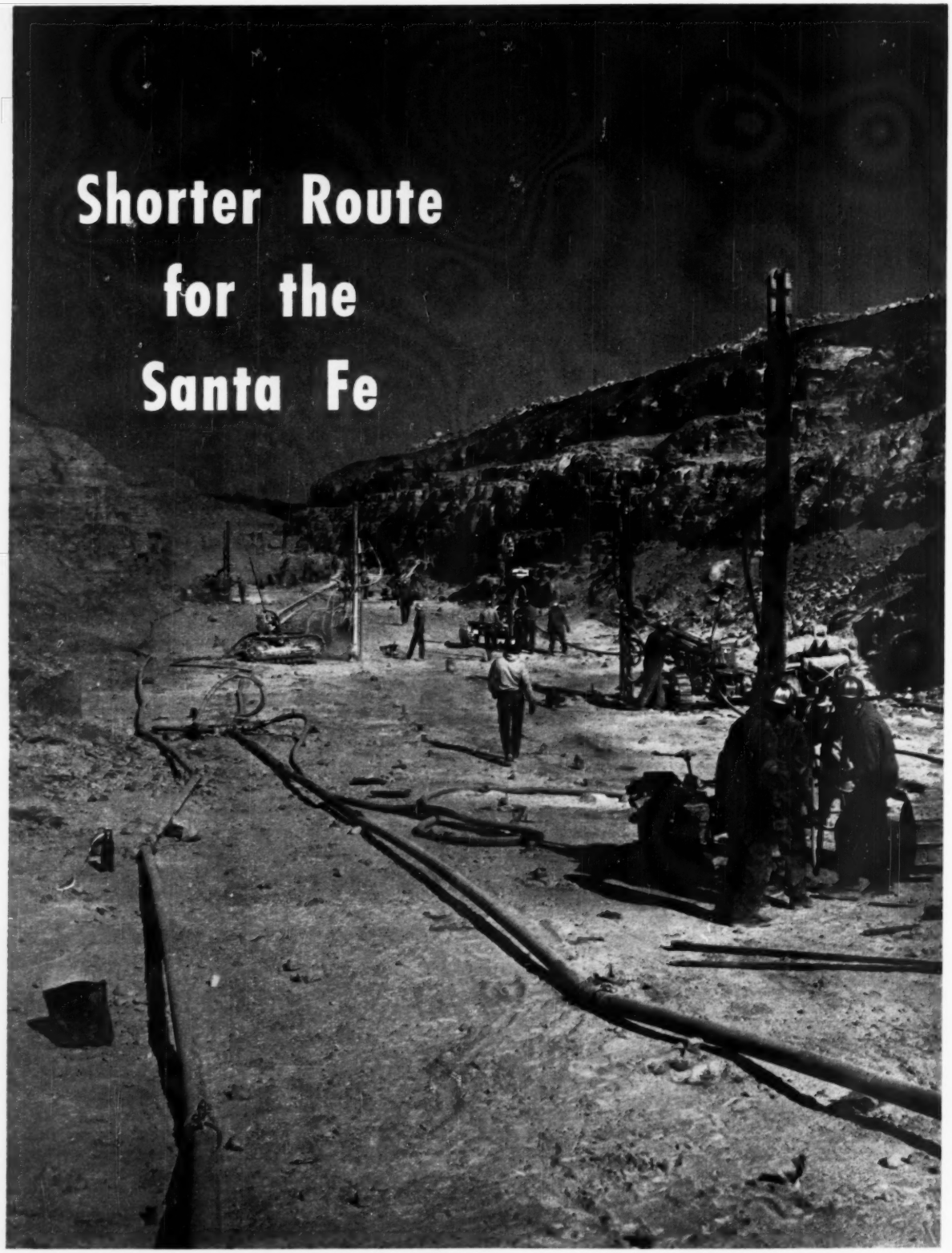


IN ORBIT At the left in the background of this sketch is the configuration of a fabric space ship that Goodyear scientists say is feasible. In the lower left, a space ship equipped with fabric fuel cells is leaving earth-orbit for the moon. At left center is a space vehicle with fabric solar heat collector, communications antenna and fuel and water bags. At the upper right, a fabric bubble is shown inflated around an interplanetary ship for maintenance purposes. Mechanics thus could work unencumbered by heavy insulated space suits.



COMING DOWN To prevent vehicles leaving orbit for earth from building up a speed at which the ships would be consumed, Goodyear engineers suggest the use, as shown, of large fabric balloons trailed behind the craft. They would provide considerable drag in the thin air at the boundary of our atmosphere, yet could be jettisoned safely when the craft had slowed to a safe and controllable landing velocity.

Shorter Route for the Santa Fe



ARIZONA ABYSS Flanked by the walls of the cut, eight Ingersoll-Rand Crawl-IR drills put down blast holes along this deepest section of the new Santa Fe line. The incision of rock in north-central Arizona is more than 2 miles long and 115 feet deep. In all, 44 miles of new right-of-way is being built to provide a shorter, faster train route.

ROCK REMOVAL One of 41 end-dump trucks on the Santa Fe job accepts a load from a Bucyrus-Erie 71-B shovel. Muck is moved to fills or spoil dumps. Some 10,000,000 cubic yards must be handled on the entire 44-mile right-of-way.

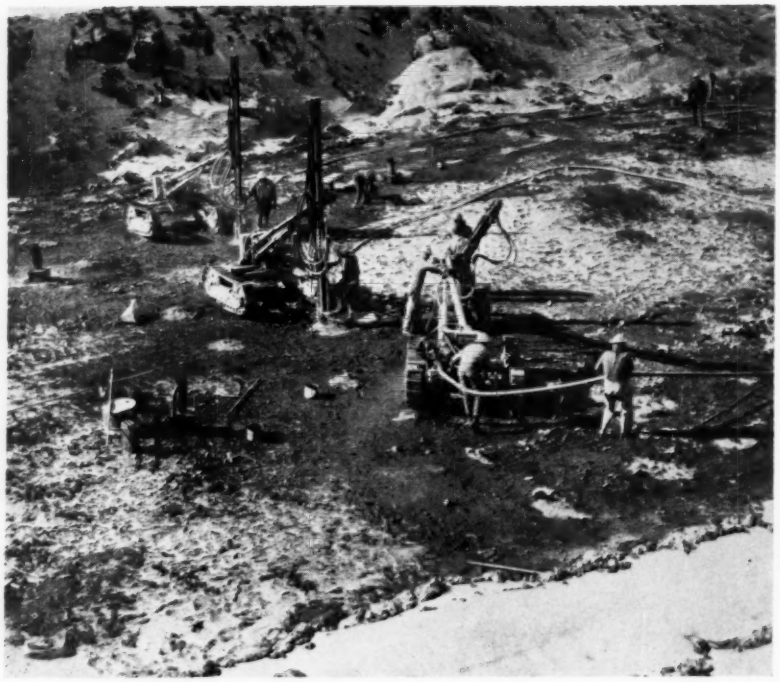
Robert J. Brown, Jr.

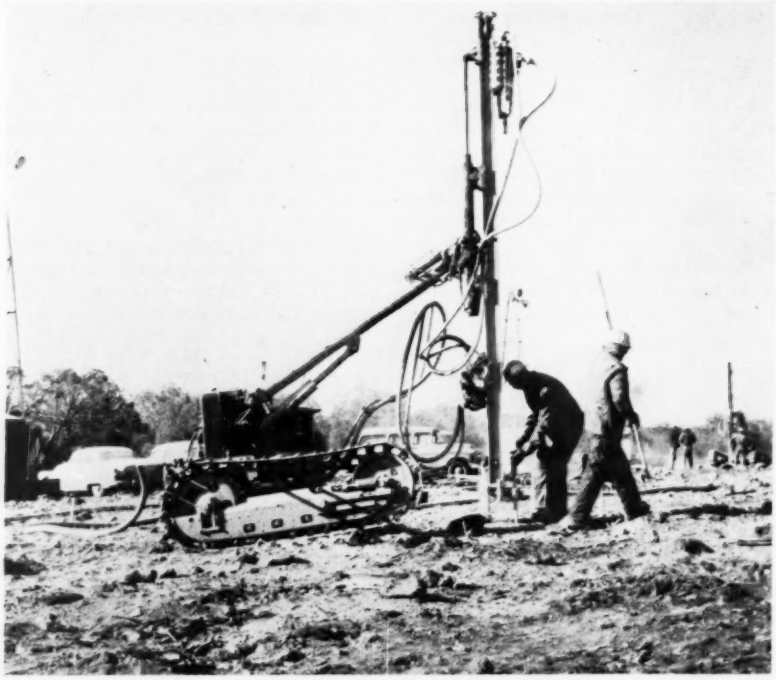
LONG past immortalized in roundhouse yarn and Tin Pan Alley lyric, the Atchison, Topeka & Santa Fe Railway now is busy with a project that should delight any modern-day bard or singer of ballads. The railroad is pushing 44 miles of new grade across a rugged plateau in north-central Arizona to give a new look to an old stretch of line.

The relocation runs between the towns of Williams and Crookton, a busy segment of the Santa Fe's main system. Morrison-Knudsen Company, Inc., is the contractor for the $19 million job, and the Santa Fe will lay and ballast its own track when the grade is finished. By slicing through terrain where construction was technologically impossible in the 1880's, the new road will have wider curves and shallower grades. These will permit the use of continuously welded rail, impossible with the existing sharp curves and steep inclines. As a result, passenger trains will save as much as an hour of running time, freights will save more than an hour, some 23 miles of track will no longer need helper engines, and a tunnel will be bypassed. M-K's men and machines are literally moving a mountain of material—10,000,000 cubic yards—to hew the path for the new route. At least 7,500,000 cubic yards of this is rock, either stubborn sandstone, or a basalt that the Indians call malpais. It is one of the West's hardest rocks. Of the remainder, 2,000,000 cubic yards is volcanic cinder and clay classified as common excavation; 500,000 cubic yards is borrow excavation.

Started in August 1959, the project was scheduled for completion by December of this year, but progress indicates it may be finished by September. The deepest cut along the route is a giant

AIR SUPPLY At right, a Gyro-Flo 900 compressor feeds air to drills beginning a cut. Above, a battery of Gyro-Flo's is placed outside the work area to keep dust from the machines. Some of the compressors as well as shovels are equipped with Farr Roto-Pamic filters that are said to increase overhaul intervals. An indicator shows when the paper-tube-type filter elements require replacement.





DRILL SCENES In the 1959–60 winter, snow reached a depth of 2 feet, as shown in these pictures, and chill winds howled unbroken across the rugged terrain. Men and equipment kept working and pushed the project near completion several months ahead of schedule. In the tough malpais formations, hole grids range from 6x6 to 6x7 feet, while 7x8 and 8x8 grids are used in sandstone. Both straight and staggered grid formations are used. Careful use of delays results in efficient blasts that break in the center first, and then shoot the perimeter into the center area. In addition, center holes are drilled about 2 feet below grade and side holes a lesser distance below in order to break rock cleanly to the grade line. Besides the rock work, M-K forces built a new bridge so that the rail line could span U. S. Highway 66, and also erected a pipeline support structure to carry a mammoth natural-gas line over the new right-of-way. Reversing the customary order of things, the pipeline bridge was built first, and then the right-of-way excavated underneath. Several other new or different ideas were tried out on the job, including the trimming of cut walls by towing discarded tractor tracks along them like a scythe.

gash more than 2 miles long, 115 feet deep and requiring some 1,300,000 cubic yards of excavation. The highest fill is a miniature mountain-ridge that towers 110 feet above its base and required some 460,000 cubic yards of material.

Besides earthwork, the relocation calls for a variety of drainage structures. These include 28 reinforced concrete box culverts, the largest a triple box nearly 270 feet long with 16x14-foot openings. Also being installed are 40 corrugated metal culverts, ranging from 36 to 72 inches in diameter, and about 30 multiplate culverts ranging from 60 to 120 inches in diameter. Near the town of Williams, concrete abutments and piers are required for a bridge to vault U. S. Highway 66.

M-K men, many of them fresh from building Southern Pacific's 13-mile causeway across Utah's Great Salt Lake, are attacking the job with an array of equipment that, as one observer put it, "would make an armored commander peacock proud." From the high end of the project (elevation 6,950) to its lower western terminus, more than 100 pieces of major equipment are at work. Some 10,000 gallons of diesel fuel and 100 gallons of gasoline are expended daily.

Spearheading the assault is a phalanx of eighteen Ingersoll-Rand Crawl-IR drills that punch blast holes into the rock. These crawler-mounted units have hydraulic booms for easy positioning. The drills put down as much as 80 feet of hole per hour in the hard malpais. Air is supplied by nineteen Gyro-Flo compressors. There are ten 900-cfm units, two 600's, three 250's and four 125's. Three-inch carbide-insert bits produce about 100 feet of hole in the malpais before regrinding. In the somewhat softer sandstone, 3-inch steel bits are used.

Six Bucyrus-Erie and two Northwest shovels, ranging in bucket capacity from $1\frac{1}{2}$ to 4 yards, scoop up the blasted rock. Toting away the rock are 37 Euclid 63-TD end-dump trucks of 17-cubic-yard capacity and four new Euclid 65-TD end-dumps of 20-yard capacity. Common and borrow excavation is handled by a fleet of scrapers, both self-propelled and tractor drawn. Twenty-six caterpillar D-8's cleared the relocation site.

For efficiency, M-K has divided its fleet of equipment into twelve spreads: seven shovel spreads, three drill, one self-propelled scraper, and one tractor-drawn scraper spread. M-K's force of 625 is headed by Project Manager Guy Reid. Harvey Hardin is general superintendent; D. R. Bagley, project engineer; Walter Forslund, equipment superintendent; Bill Beatty, office engineer; and Robert Woodhead, office manager. For the Santa Fe, R. A. Stane is construction engineer, and Troy Ary is resident engineer.

FIRST ENCAMPMENT Expecting 4000, some 50,000 actually turned out. The photograph was taken at Desolation Canyon, and in the background can be seen the long string of automobiles that were stranded along the road.

PHOTO, AUTOMOBILE CLUB OF SO. CALIFORNIA

Death Valley Revisited

The annual '49ers Encampment revives the saga of the Argonauts of 1849

Hazel M. Spell

MARKER One of the projects undertaken by the Death Valley '49ers is the placement of markers such as this one at Stove Pipe Wells. It reads: "Near this monument, Jayhawker group of Death Valley Forty-Niners, gold seekers from Middle West, who entered Death Valley in 1848 seeking short route to mines of central California, burned their wagons, dried the meat of some oxen and, with surviving animals, struggled westward on foot."

PHOTO, AUTOMOBILE CLUB OF SO. CALIFORNIA

CALIFORNIA stages many celebrations commemorating its historical days, but for many, the Death Valley '49ers Encampment is the historical and recreational acme. Each November, it recreates the story of pioneers who paved the way for western expansion—and does so more graphically than any wide-screen film or television weekly.

The '49ers celebration is possible because of the work of a group dedicated to preserving the memory of those hardy travelers who, having heard of J. W. Marshall's find at Sutter's Sawmill on January 24, 1848, braved the desert to find their El Dorado. Government officials; professional and business men; writers, artists and others drawn by the desert: all provide historical knowledge and entertainment for the crowds that flock to that valley of mystery and beauty. The 4-day celebration attracts visitors from every state in the U. S., as well as from several foreign countries. Once they visit there, many return.

When California planned its 1949 centennial, the idea of portraying the entrance of the pioneers into Death Valley was conceived. The scene was to be Desolation Canyon. Los Angeles, San Bernadino, Inyo and Kern counties joined in underwriting the expenses. A Hollywood script writer was then employed, but his plan proved too unrealistic. It was discarded; a true picture of the heroic struggle was used instead. Andrew Noon, then Chairman of the Kern County Board of Supervisors, served as chairman for this initial celebration. It was such a success, the county debt was retired within 2 years.

Temporary grandstands were erected, and accommodations prepared for a crowd of 3000–4000. When the Encampment began, however, an estimated 50,000 poured into the area. Many more were stranded along the way, unable to drive farther, and camped out where they stopped.

With overwhelming popularity seemingly assured, the original group decided to form an organization to hold yearly encampments. They called the nonprofit group the Death Valley '49ers and elected directors and officers—all men and women dedicated to public welfare and preservation of Death Valley history. These officers serve without pay or reimbursement. To help finance the operation, memberships are sold at prices ranging from $2 for an active member to $100 for life membership. The thousands who have subscribed invariably find it an honor to be a '49er.

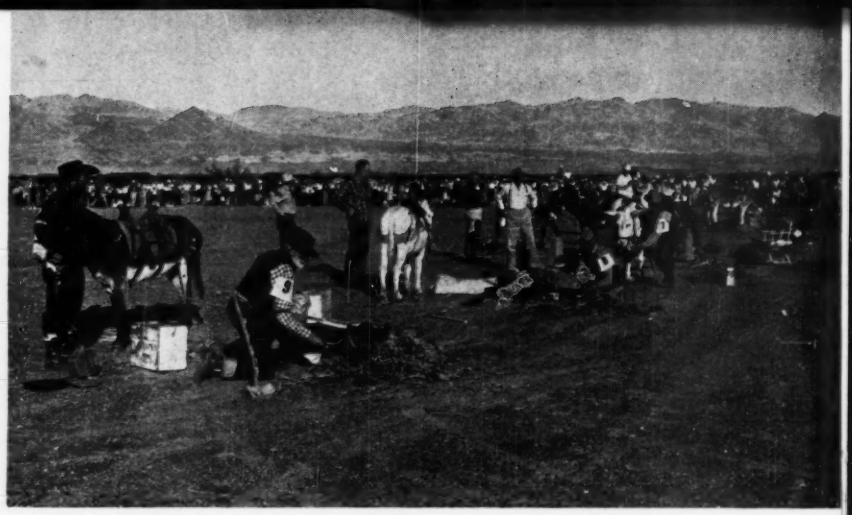
The encampments provide free entertainment and education for everyone: evening campfires with music and informal talks; square dancing on the patio and porch of Furnace Creek Ranch; an intriguing display of old-fashioned guns. There are displays of various minerals of the state, and outstanding Western art is always on exhibit at Furnace Creek Inn.

Highlights of a typical Encampment are breakfasts served on the golf course adjacent to the Furnace Creek Ranch, where coveys of quail scurry about the

date trees and the white and pink tamarisk bushes. One is the artists' breakfast during which painters explain their year's work; the authors' breakfast features prominent writers who entertain with informal talks; and the photographers' breakfast is for amateurs as well as professionals.

Every visitor remembers the famed Burro Flapjack Sweepstakes held at Stove Pipe Wells, a place named for its plentiful, if mineralized, water. It is invariably a scene of merriment and thrills, complete with ox-drawn covered wagons and riders costumed as '49ers. The guards even carry muzzle-loaders for protection. It is especially exciting when the burros live up to their proverbial stubbornness.

Motor tours are conducted by Monument officials to various spots of interest throughout the Valley. Hundreds of visitors drive to such intriguing points as Dante's View, from which the White Mountains define the northwest horizon and the Sierra's, the west, with the Valley spreading some 6000 feet below. Another is the old Borax works, of interest because the salt, an almost pure borate of lime in Tertiary lake beds, opened a new era of industrial development for the area. Scotty's Castle, near the Grapevine Canyon access into Death Valley, is also popular. It belonged to the famed Walter Scott, formerly a rider in Buffalo Bill's wild west shows, and later a hermit.



STUBBORN FUN The famed Burro Flapjack Sweepstakes contest (above) takes place at Stove Pipe Wells. Les Spell is in the foreground (No. 9), and the picture comes from the author's collection. The two Spells were the co-authors of "Forgotten Men of Cripple Creek," a history of that well-known mining camp.

Death Valley Monument itself was established in 1933, and contains more than 2900 square miles cradled between the varicolored mountains. The 140-mile-long, curved, trough-shaped desert is only 6 to 15 miles wide. Overhead is usually a clear sky, but when it is cloudy, the sunsets are especially colorful. Some 500 square miles of the park are below sea level, with Badwater its lowest point—about 280 feet below sea level. Curiously, it is only 80 miles from Mt. Whitney, formerly the highest (14,495) peak in the United States. Both can be seen from Dante's View.

Most of the valley lies in a basin in Inyo County, immediately north of the Mojave, between the Panamint Valley on the west and the Amargosa Desert on the east. The western wall is formed by the Panamint Range, rising 6000 to 11,000 feet. The eastern wall is a group of mountains—the Grapevine, the Funeral, and the Black—that rise to heights of 4000 and 8000 feet. Last Chance Range is at the north; the south is bounded by the Avawatz and the Owlshead mountains. Through these runs the Amargosa River as it bends northward having circled the southern tip of the Black Mountains. The Amargosa (Spanish for "bitter one") is saturated with Glauber's and Epsom salts. It disappears in the sands, heat and salts of the Valley.

Almost the entire record of geological time is recorded on the mountains, though faulting, tilting and folding have made it nearly impossible to read. During the Mesozoic it is thought that the Valley was a region of low mountains and wide valleys, full of lakes and streams. Many earthquakes and much volcanic action covered the area with flows of volcanic mud and lava, and with fragmental material accumulating and forming tuffs. Death Valley was created as a result of the faulting.

Death Valley was a desert for a long time thereafter, but was later filled with water. The lake eventually evaporated and the desert reappeared. The only major change in the terrain during the last few thousand years has been from erosion, the accumulation of debris in the Valley, and the formation of Ubehebe Crater. The last-named was given the Indian word for Big Basket in the Rock and describes it well. It is an inverted cone, half a mile in diameter at the top, 800 feet deep, and 450 feet

PROSPECTOR The year is not 1849, but 1953; however the two seem interchangeable in this picture. Leslie D. Spell was the Sweepstakes Winner in the Burro Race and is shown here in what was termed the most authentic prospector's rig of the contest. Spell is often referred to as "Dean of Prospectors." Some of the barrenness of the desert landscape and the wiryness of prospectors is implied here.

BREAKFAST Although the green grass and date trees in the background would make one think of a Mediterranean port, it is actually one of the oases in Death Valley—Furnace Creek golf course. It is the sight of the artists' breakfast. The creek's water remains at an almost constant 74° F.

PHOTO, L. BURR BELDEN

in diameter at the bottom. Actually it is an explosion pit that did not build a large cone. The volcanic action that caused it probably occurred within the last 1000 years.

The desert is a land of exaggerations—of blasting temperatures and reports of fantastic riches. The riches were not the silver lodes expected, but vast mineral salt deposits. As for the temperatures, they range from delightful fall and spring days with warm sunshine, to the cool evenings of December and January. The thermometer seldom registers freezing. During late June, and continuing through mid-September, the heat is concentrated, though, with highs in the 120-degree range. The nights are also hot during this time, with temperatures rarely falling below 85° F. Driving through the Valley in summer, the metal fixtures of an automobile become hot enough to burn the skin. Perspiration dries almost instantly, leaving a sandy salt deposit coating on the skin.

November is ideal, however, and campers will find every facility provided at the Encampments. For those who don't prefer to camp out, Furnace Creek Inn and Ranch at Furnace Creek, where the 74-degree water promotes lush vegetation, and the hotel at Stove Pipe Wells, provide eating and sleeping quarters during the season—if reservations are made well in advance. Publications detailing a variety of Death Valley lore, facts, music and geology are on sale at these oases. Proceeds from their sale are used for the '49ers organization and help pay for the Death Valley Museum that is under construction.

It is hoped that the museum will be dedicated during the 1960 Encampment this November. The land for it was donated by the U. S. Borax Company, and some State Park funds have been used in its construction. Much valuable material has already been collected for the building, and many more mementos are being assembled by a committee headed by Ardis M. Walker and L. Burr Belden. This is just one of the pursuits of the Death Valley '49ers.

Another important task is the establishment of markers at strategic points along the 1849 trails, such as the spot at Stove Pipe Wells where wagons of the desperate travelers were burned to provide fuel to smoke meat of the oxen they were forced to slay. There is also the Wade Memorial placed on one of California's highways to mark the spot where Harry Wade and his distraught family found an exit from Death Valley. Members of the present '49ers have made tortuous journeys to retrace routes of the early passers, thereby providing specific spots for these markers.

Death Valley National Monument officials and rangers lend assistance to travelers who flock in with house trailers and camping equipment of every description. They come over good roads that were once ox cart paths and foot trails. When they arrive in the desert, ample pure water, adequate parking space, and sanitary facilities are provided; and the roads leading to Death Valley and surrounding points of interest are well maintained. A true spirit of camaraderie prevails; new friendships are made; many old acquaintenances are renewed.

CAMARADERIE Everyone joins in the fun during the '49er Encampment and shows a spirit of co-operation, as seen in this campfire picture. Using blankets at night is not unusual in the desert during November; were it midsummer, the story would be much different.

PHOTO, AUTOMOBILE CLUB OF SO. CALIFORNIA

This and That

Australian Language Survey

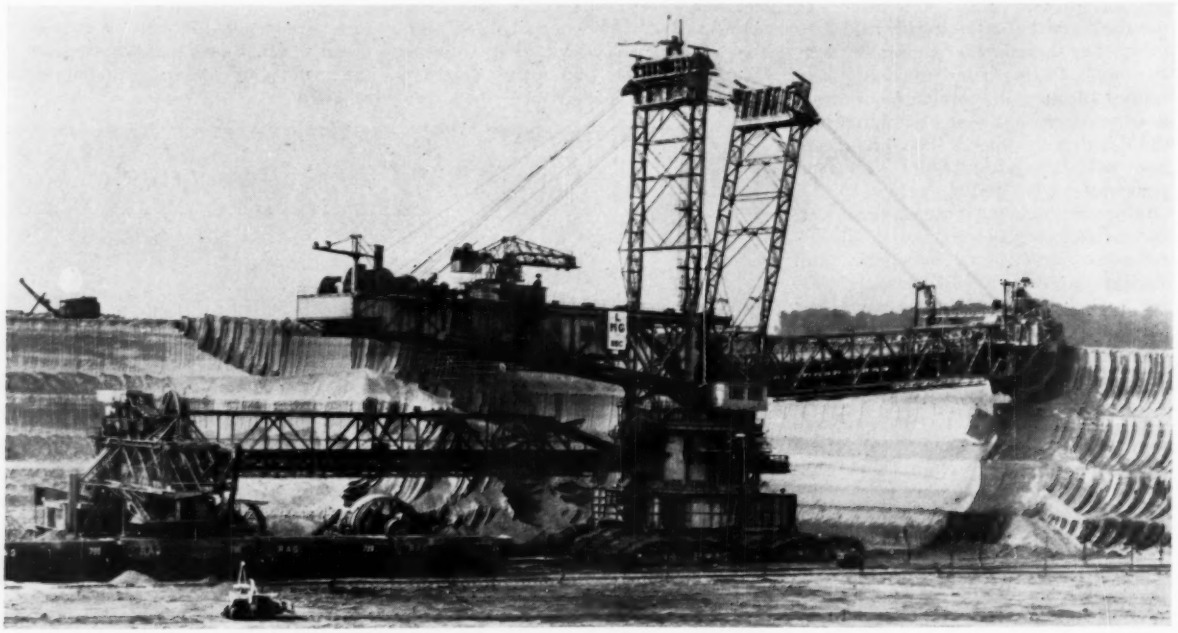
English spoken in the land of wombat and Waltzing Matilda is receiving a thorough examination. Making the survey are Prof. A. G. Mitchell, head of the English Department at Sydney University, and Arthur Delbridge, a radio commentator concerned with the language down under. Voices of 25,000 Australians have been recorded and will be analyzed and tabulated to indicate such qualities as abberations, nasality, assimilation, and intonation. Note will be taken of so-called "broad" Australian and "educated" Australian and the drawled, slow, normal or fast tempo of talking. When all the information has been tabulated it will be fed into an electronic computer for scrutiny. In a few minutes the investigators will know, for example, whether there is truth in the contention that Australians say the name of their continent "Austrylear" instead of "Austrailya." The analysis of 25,000 voices should have significance for the continent's total population is about 10,000,000. About one person in ten in Australia has fairly recently come to the country, and this has spurred interest in language study.

★ ★ ★

Long Range Repair Job

When satellite telemetry stations informed Robert E. Gottfried of Space Technology Laboratories, Los Angeles, Calif., that temperature reports from Pioneer V were inaccurate, the engineer was faced with a problem. He couldn't grab his circuit diagrams and take along a technician to repair the malfunction for Pioneer V happened to be some 5,500,000 miles out in space. Gottfried, who had helped develop the 11-pound component that converts Pioneer V's analog information into binary digits for transmission back to earth as numbers, set out to analyze the malfunction. He began by narrowing down the potential trouble points from the 1500 diodes, 1600 resistors, 1000 capacitors and many connections inside the satellite. To indicate values for eight variables in sequence, the 10-bit "word" transmitted by Pioneer V back to earth is composed of four identification bits and six information bits. The identification numbers appeared to be all right so Gottfried began to scrutinize the information numbers. Soon he began to suspect that the culprit was a diode circuit in the 6-stage counter. (In such a counter, each of the six stages can be in either of two stages. Change from one stage to the other indicates the next higher count. A short in a particular diode circuit would freeze that value, whereas an open diode would result in the failure to transmit a certain group of numbers correctly.) An open diode was found to be the trouble and Gottfried derived a formula to find which numbers could be transmitted for each of the possible malfunctions. These results were then compared with data received and the 1 diode circuit in 26 which had opened was located. The final step was to devise a translation

FERRIS WHEEL FOR OVERBURDEN



The mechanical giant in this picture can dig some 13,000 cubic yards of dirt per hour and deliver and load it in rail cars. Built in Western Germany by Orenstein-Koppel und Lubecker Maschinenbau AG and sold in this country by Link-Belt Company, the LMG bucket wheel excavator was developed early in the 'thirties for excavating overburden and brown coal in German open pit mines. Since that time, its operating economies have led to the unit's adoption in other parts of the world in a variety of sizes. The one shown above with the 13,000-yard capacity has a wheel 52 feet in diameter. Link-Belt will be responsible for all U. S. sales and in addition will handle engineering involving high-speed belt muckers.

code to show the possible alternative value for each of the eight variables. Looking over prior, correctly transmitted data permits selection of the right value.

★ ★ ★

More About Zippers

Whether or not the adjective *ubiquitous* can be applied to the zipper, the manufacture of which was discussed in our July issue, was the subject of much discussion in our editorial offices. A curious item arrived shortly after we had gone to press that seems to bring an affirmative decision. Alex E. Spalding, a Winnipeg, Man., lexiography student, has published what he calls "an adventure and a labor of love." It is a grammar in English of central and eastern Arctic dialects. (Eskimo grammars have been published in Danish and German, but they were based on Greenland and Labrador dialects.) As an aid to his grammatical points, Spalding utilizes a vocabulary which includes siktaktok—meaning, of course, zipper fastener.

★ ★ ★

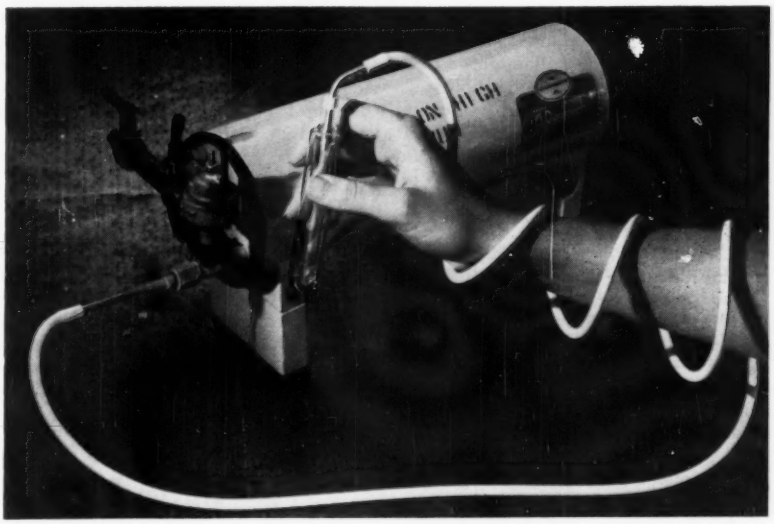
Polaris Boosted By Air

A battery of steel flasks, each nearly 4 feet in diameter, provided the big blast for the U. S. Navy's first undersea battleship when it joined the fleet recently. Sixteen of these giant flasks are ranked in two rows of tubes that house the "big guns" of the SSB(N) *George Washington*, prototype of a new class of nuclear submarines that will launch Polaris ballistic missiles at enemy targets while lying hidden under the sea. Each flask is built to withstand an internal pressure of 7000 psig and will be filled with compressed air. The air serves as the big boost that shoves the Polaris free of the sub and into the air before ignition of its powerful rockets. The flasks are built up by Lukens Steel Company from two heavy-gauge steel hemispheres hot-pressed from HY-80 plate, then welded together.

★ ★ ★

Cryogenic Cooling Phenomenon

The efficient transmission of liquefied gases used for cryogenic cooling may be revolutionized by a phenomenon recently discovered by scientists at AiResearch Manufacturing Company. Using unique, uninsulated lines, AiResearch, a subsidiary of Garrett Corporation, has transmitted liquid nitrogen at −320° F over distances greater than 25 feet. Previously 6 feet was the maximum. Though the transmission lines have no insulation or lagging, their exterior remains frost-free and may be safely and comfortably manipulated with the bare hands, even though the liquid inside is so cold. A further advantage is that flexible plastic lines may be used which greatly simplifies the delivery of cryogenic refrigerants to moving elements. Illustrated here wrapped about the wrist of the demonstrator, the system is considered patentable and letters have been applied for by AiResearch.



★ ★ ★

Pneumatic Umbrellas For Miners

When consolidating vertical or steep shafts, the risk of falling debris often makes it necessary to work from the top down. The rational solution would be, of course, to proceed from the mine gallery upward. A Swedish mining company found a solution in the form of an "umbrella." It is rubber plug that is inflated to provide a resilient shield over the consolidation crews and is moved up with the progress of the work. The plug looks like a rubber balloon with a nylon cord reinforcement. Its walls are 0.118-inch thick, and where added protection is required, gunny bags filled with, say, wood shavings, can be placed on top of the plug. The method was successfully utilized for the consolidation of shafts up to nearly 600 feet.

★ ★ ★

Tic-Tac-Toe

Our man in Upstate New York recently found himself far above Cayuga's waters, wandering down the not-so-ivy-covered halls of the computing center at Cornell University and "overheard" the following conversation:

"You may have the first play, Sir. I play in square 1, your turn, Sir. I play in square 3, your turn, Sir. I play in square 2, which wins for me. Thank you, you played well, but the better man (machine) won." As he started to continue on his reporting errand, he was detained by another fragment of conversation:

"You may have the first play, Madam. You did not enter your play, please start again." Nonsense, our man thought, but with the words "Naughty, naughty. You did not play fair last time. If you promise not to cheat we can play again." He decided to inspect. It was the dedication of the university's new Burroughs 220 computer in Rand Hall. The device was having fun with the faculty, but is now doing a more practical set of chores. The unit, with a paper tape photo reader capable of reading 1000 alpha-numerical words per second, can eliminate much work. For example, a 3-inch metal cube at 500° C immersed in water at 0° C would require 30 hours of mathematical computation per minute of cooling to chart temperature progress mathematically before its temperature at the core dropped to that of the water. Using the 220, it would require just 12 seconds to do the same amount of calculation.

There are about 2000 researchers in the United States who are familiar with the use of computers, and comprise all types of scientists. In this way, the chance of a major discovery is better than in, say, Russia, where about 400 mathematicians are gathered together in one center located in Moscow and on whom all industry must call to obtain calculations. The hourly operating cost of the 220 to the various departments at Cornell is $150; graduate students and others pursuing legitimate research projects are permitted to use it free of charge. Incidentally, our man reports the center works on a 24-hour schedule to handle the work load.

New Way To Save Diamonds

An improved process for the reclamation of industrial diamonds from machine wiping cloths has been developed by Springfield (Mass.) Armory. Earlier methods generally resorted to burning or decomposing the cloths by acid or alkali to recover their diamond fragments. The new process which is said to be faster and more economical is not only safer for personnel handling the chemicals, but requires a smaller expenditure of materials and labor. It salvages 5 to 9 percent of the fine diamonds formerly wasted too. In the system, 1-pound lots of diamond-bearing cloths are put through an ordinary, portable-type washing machine, provided with a wire mesh screen over a false bottom. Synthetic detergent is used. The residue from the first washing is fused in caustic solution, cooled and dissolved in water. This oxidizes carbon and tungsten. Further washing rinses out the alkali before boiling in concentrated hydrochloric acid. The diamond particles are separated from the residue after it has been cooled and washed. Infused with thallous formate and subjected to steam bath, the liquid at a specific gravity of 3.5 releases its diamonds to the surface, where they float clear of other associated abrasives. The cloths are reprocessed in the same manner, but in $^1/_2$-pound lots, and more diamonds are thus gleaned from them. The accumulated diamond bits are finally dried and weighed on an analytical balance. The recovery method is reported to be 95- to 99-percent efficient.

★ ★ ★

Engineering Scholarship Brochure

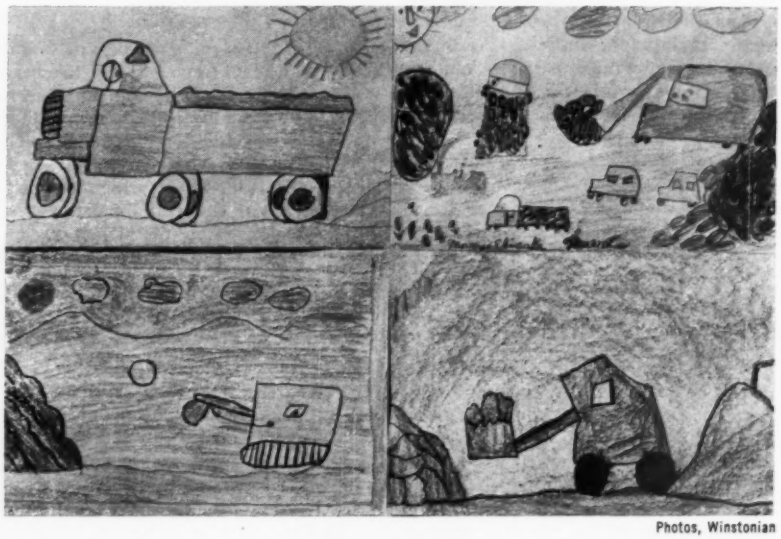
The Hertz Engineering Scholarship Foundation has issued a 12-page brochure that gives details of the group's scholarship program. The foundation is a nonprofit private institution devoted exclusively to the granting of engineering scholarships to students interested in electrical, mechanical and allied engineering fields. The publication compares many of the basic principles of the United States' technical educational with the Russians', and offers reasons behind the recent rapid technical development of the Soviets. It also discusses the decreasing number of our high school graduates who go on to an engineering education, as well as the 100,000 high school graduates who yearly fail to go to college because of insufficient funds. It is toward this large core of "wasted manpower" that the scholarship foundation is aimed. The brochure also explains how American industry and individuals might help alleviate the shortage and waste of scientific and engineering capabilities by channeling tax deductible funds into sponsored scholarships. A copy of the brochure may be obtained by writing to the Hertz Engineering Scholarship Foundation, 1314 Westwood Boulevard, Los Angeles 24, Calif.

★ ★ ★

Terrestrial Solar Chariot

In Los Angeles, Calif., the city of The Great Smog, International Rectifier Corporation, El Segundo, demonstrated an auto that does its bit toward an uncontaminated atmosphere. The car is an immaculately restored 1912 Baker Electric powered by a bank of 10,000 silicon solar cells on the roof. The world's first sun-powered car is largely the work of Dr. Charles Escoffery, who led the project for the electronics company. The vehicle was built to point up the expanding versatility of solar energy and the feasibility of electric automobiles for city driving. While the car is not exactly the thing for turnpike cruising at the moment, it will serve as a research tool as well as a successful publicity medium. Doctor Escoffery, a physical chemist, delivered a paper on "Photovoltaic Conversion of Solar Energy" to the American Power Conference last March.

Crayon Posters from Terminus Dam



Photos, Winstonian

THE four pictures reproduced above were drawn by third graders from a school in Woodlake, Calif., after they had visited the nearby Terminus Dam project. Apparently the big shovels were most impressive to them.

The project is a joint venture awarded to Winston Bros. Company and Green Construction Company, under the coordination of the U. S. Army Corps of Engineers, Sacramento District, and is scheduled for completion in April 1962. The project is located on the Kaweah River about 20 miles east of Visalia, Calif., in the foothills of the Sierras. The main structure is to be a rolled earthfill dam with a maximum height of 250 feet and a crest length of 2375 feet. An auxiliary dam will be required to contain the reservoir at a saddle traversed by State Highway 198, which is being relocated by another contractor. Also of rolled earthfill construction, it will have a maximum height of 130 feet and a crest length of 870 feet. Included in the work is a 1300-foot-long diversion tunnel that finishes to 12 feet 9 inches in diameter.

Each dam will consist of an impervious central core with outer pervious zones. The impervious and pervious materials will be obtained from areas upstream and downstream from the dams. Rock for the random rock zones in the outer portion will be obtained from the required excavation for the spillway.

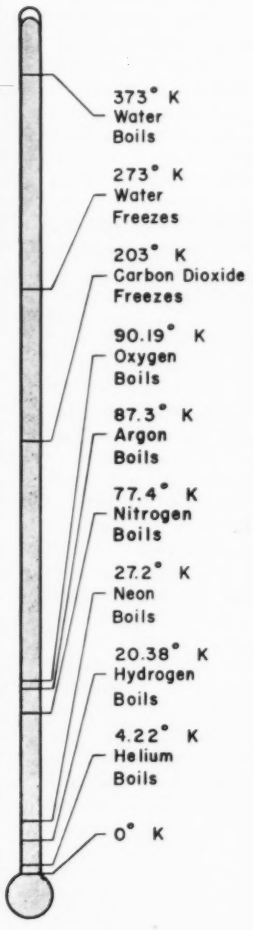
When completed, the resultant reservoir will have a storage capacity of 150,000 acre-feet, of which 8000 acre-feet will be inactive space reserved for sediment storage and other project purposes. The dam will keep the Kaweah River in check and protect the rich farming areas downstream, for the not-too-large Kaweah occasionally rampages following heavy snows and rain in the Sierras. Since 1937, there have been ten major floods, the largest being at the end of 1955 when damages amounted to nearly $12,000,000.

EDITORIAL

Kryos

GREEKS had a word for cold, a subject that got quite a bit of attention in ancient Hellene. From that word, *kryos,* are derived such modern ones as cryogenics, cryostat and cryotron. The low temperatures they imply are literally farther from the original meaning of kryos (ice cold) than is ice from steam. The common cryogenic fluids (argon, fluorine, helium, hydrogen, neon, nitrogen and oxygen) all have boiling points more than 300° F below the freezing point of water. Saturated steam, of course, is 180° F away from zero—in the opposite direction.

We know quite a bit more about cold—or more exactly, the absence of heat—than did the early Greeks. Some of their philosophers speculated, for example, that diamonds were ice crystals that had been frozen so hard in the cold lands of the North that never again would they thaw. Even so, however, it's only been in the last few years that engineers have taken an interest in the actual workings of gadgets at low-Kelvin-scale temperatures. Most all of the devices that have left the laboratory for experimental commercial use are ones that make use of the newly discovered superconductive electrical properties of metals that show up when the metals are cooled to temperatures in the liquid helium range (4.2° K).



ALTHOUGH the cold world of cryogenics has only been, until recently, a subject for laboratory work, cryogenic principles have been widely used for many years in air fractionation plants where many industrial gases are produced. The science got its start in the eighteenth century gas liquefaction experiments of Rumford, Faraday, Joule, Rankine, Kelvin (whose temperature scale is depicted on this page), Linde and many others.

The rate at which these gases are produced is often astounding. In May, for example, 1244 million cubic feet of nitrogen gas was produced, 111,494 short tons of low purity oxygen and 52,219,000 cubic feet of refined argon. Practically all of these gases and some others, too, came from cryogenic air fractionation plants.

Space age research has also brought about a boom in cryogenics. In addition to the testing of materials suitable for operation in the chill reaches of outer space, the very fuels of our advanced rockets are within the realm of cryogenics. In this month's article beginning on page 8 is related the story of how liquid hydrogen is turned out in tonnage quantities. The primary reason that liquefied gases are required in rockets lies in the liquid-to-gas ratios of those commonly used. One gallon of liquid hydrogen makes 114.3 cubic feet of the gas for example, and 1 gallon of liquid oxygen vaporizes to fill a volume of 115.3 cubic feet at normal temperatures and pressures. Even when highly compressed, the gas to liquid ratio is such that it would be impractical to carry these fuels into space in the gaseous form.

ADVANCES in technology that have made possible work at near-absolute-zero temperatures are linked quite closely to advances in mechanical equipment. Prominent among such items are gas compressors. Cryogenics is a field that is necessarily based on compressors. The Joule-Thompson effect and the method of making a gas give up heat by doing mechanical work in expanding are the only ways by which the required refrigeration in quantity can be obtained. This, of course, presumes considerable compressor capacity. Indeed, the means of coming by the temperatures of cryogenic research are removed in degree only from standard refrigeration techniques. A gas is compressed, cooled to remove the heat of compression and then expanded to chill it far below the original temperature, just as occurs in refrigerators and freezers. By repetitive compression-expansion operations, near-absolute-zero temperatures are developed.

Such techniques, of course, are far from new. The problem has been in extending the theory to plants capable of producing literally tons of the cryogenic gases economically. One of the more recent advances in reciprocating compressor technology that has aided this is a single-machine frame mounting cylinders for a variety of uses. On one, air and nitrogen are compressed, and nitrogen is expanded to produce refrigeration (returning energy to the compressor crankshaft). On another machine, two different gases are compressed to relatively high pressures in separate cylinders while another takes suction at below atmospheric pressure and discharges to atmosphere.

In the realm of centrifugal machines, a recently developed intercooled unit has been applied to an air fractionation plant as the main air supply. This blower, through an ingenious internal arrangement of piping, makes possible the use of a single comparatively small 5-stage centrifugal compressor to efficiently furnish extremely large quantities of air at pressures in the 100 psig range.

STORING and handling cryogenic gases have applications for compressor equipment too. Vacuum insulated lines are, to date, the best way of controlling heat leakage into piping systems. Even insulation volume filled with so-called solid insulators is evacuated. For the lower temperature gases, a unique system is now under development in which other gases with much higher freezing points are put into annular spaces surrounding liquid gas storage tanks. At normal temperatures, pressures in the insulation spaces are at about atmospheric. When the tank is filled with a liquid gas however, the insulating gases condense, then form crystals, thus developing high vacuum within the insulation space.

There is, we feel, little doubt that cryogenics looks to compressed air and gas technology as a starting point, as do so many other sciences.

Interstage Condensate Control System

STEEL-MAKING requires tons of oxygen. At the Clairton (Pa.) works of United States Steel Corporation, the oxygen generating system utilizes a high-pressure, 4-cylinder, horizontally opposed compressor, direct-connected to a 2000-hp, 450-rpm electric motor. Between each stage of compression the compressor has an interstage receiving vessel into which the high-pressure gas is exhausted from the preceding cylinder. In making the oxygen generator plant automatic, it is necessary to detect the level of the condensate precipitated into the bottom of these receiving vessels as the gas is exhausted into the vessels. Should the level become too high, pressure in the vessel would approach that of the interior of the cylinder, thus preventing exhausting of the cylinder into the receiver.

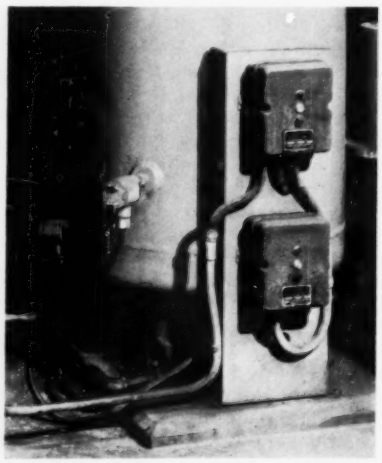
Specifications required a detection system to monitor the critical levels. The system would actuate flushing equipment to dispose of the condensate. It also was to be corrosion resistant, unaffected by high pressures and was to fail safe.

Level-Tek

The device finally selected was designed and manufactured by Aeronautical Instrument Division, Robertshaw-Fulton Controls Company. It is called a Level-Tek Capacitance System. It is a Teflon insulated probe connected to an inductance/capacitance bridge by a coaxial cable. The bridge circuit is essentially a Hartley oscillator. This is designed to oscillate under either of two conditions: when the capacitance of the probe, determined by the dielectric constant of the material between the body of the probe and the wall of the container, increases (as would occur when the device is to be triggered with an increasing materials level); or when the capacitance of the probe decreases (as would occur when the level of material falls below the probe).

How does it work? When the material rises to the level of the probe (or falls below its level, depending on the circuit used) the circuit begins to oscillate. When this occurs, plate current decreases and the relay armature "falls out." The relay contacts operate a set of indicator lights, while the armature actuates an electrical snap switch to control external equipment.

Since no mechanical measuring means are used with the level detection system, virtually any solid or liquid material can be measured. To facilitate this, Robertshaw-Fulton provides a variety of probes, including those that will detect stoppages in feed pipes, flexible probes for vertical placement of coarse solids, rigid probes for fluid or gaseous measurement, and special concentric shields for liquid detection.



SAFE PROBES Shown is a close-up view of an interstage condensate receiver with its two Level-Tek systems. The one in the background is the normal system; the device above it and in the foreground, the safety system. Controls and indicators for the entire blowdown control system are centralized on a master annunciator board (not shown here), part of the master control center for the oxygen plant.

Fail-Safe

Since operation of the Level-Tek system consists of the circuit oscillating and thus causing the relay to de-energize, the fail-safe properties desirable are inherent in the design. Should a malfunction occur, the relay would de-energize in the same manner as if material level had reached the actuation point. Further, the probe is self-cleaning, and being made with Teflon insulation, residue remaining will not cling to the smooth surface. Hence the probe cannot become coated and indicate falsely.

At Clairton

As an added check feature at the U. S. Steel plant, two Level-Tek systems are installed on each interstage receiver vessel. One is the "normal" system; positioned slightly above this is the "safety" system (*see illustration*). Should the former fail, the safety system would eventually be activated as a result of the increasing level of condensate. When the safety Level-Tek functions, it sounds an alarm and shuts down the compressor to prevent equipment damage.

The normal probe operates when there is sufficient condensate to warrant blowdown by actuating a solenoid pilot valve to open a larger pneumatic valve. Pressure in the vessel then causes the discharge of the condensate. This cycle lasts between 0.2 and 0.5 second from initiation to closure.

Probes utilized in the system are installed in the receivers at the levels where actuation is desired, extending horizontally into the receivers and insulated from them. The receiver wall becomes a part of the capacitor formed, the coaxial cable connecting the wall and the probe to the oscillator circuit. When the dielectric constant between the probe and the wall increases, grid bias of the oscillator circuit increases and oscillation starts. With the dielectric constant of air unity, or one, the approach of other material within the receiving vessel will cause an increase in capacitance between the wall and the probe, thus causing operation of the circuit to de-energize the relay.

As a receiver vessel is located at each stage of compression at Clairton, and since there are four stages in the installation, a total of eight Level-Tek systems are installed, two in each receiver vessel. Any of the safety detectors will shut down the compressor. Each of the normal detectors causes its own receiver to blow down.

Heat Exchanger Cleaning

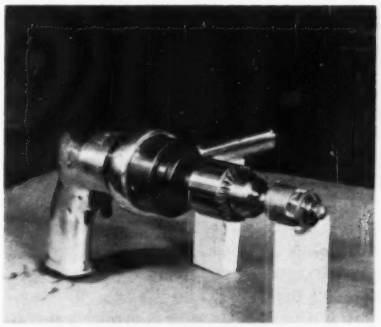
SAVING WITH AIR POWER APPLICATION

IN GENERAL, heavy-duty heat exchanger cleaners are large units that must be suspended from a frame. Erection of the suspension rigging naturally adds to the time and cost of the project. As with maintenance of many large components, down time is the biggest problem because every minute the machine isn't working is shockingly expensive. What was needed was a lightweight versatile unit that could be put right to work and could do its job quickly.

The Elliott Company's Lagonda Division at Springfield, Ohio, developed such an instrument and called it the 5124 cleaner. It is an air-powered, pistol-grip device powered by an Ingersoll-Rand 1AL Drill. Elliott builds the waterfeed attachment, hollow shafting and a variety of drill attachments. In use, for example, an operator runs a brush on a long shaft through the tube. Previously used pistol-grip exchanger cleaners have often been unsatisfactory because of their tendency to stall, even under a light load. This one has enough punch to drill through a concrete or brick wall but weighs only 7 pounds.

Power comes from the drill's high-speed air motor, reduced through planetary gears to a governed maximum of 1500 rpm. This is considered the ideal speed for a heat exchanger cleaner. Moreover, the shaft governor provides an important safety feature—it prevents shaft whippage that ordinarily is developed when an air driven cleaner is not under load, as when it is first started into the tube.

There is another advantage to the versatile unit. A Jacobs chuck can be substituted for the waterfeed attachment to drive other accessories. An example is a tube trimmer (shown below); it pares the ends of condenser or heat exchanger tubes after rolling.

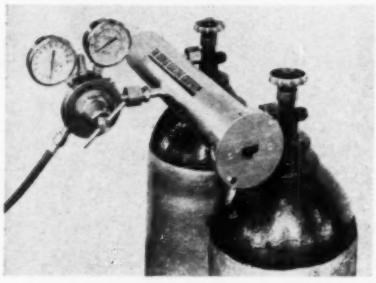


TWO USES **The large picture shows the Elliott 5124 cleaner in operation. The Ingersoll-Rand driver is held in the right hand; ahead of the operator's left hand is a hose leading into the waterfeed attachment. Shafting runs to the brush end. The small picture at right shows another use for the air-powered tool, as a tube trimmer.**

Industrial Notes

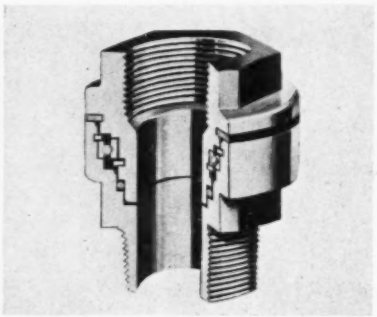
TO PRODUCE more perfect compaction of stiffer concrete mixes, Ingersoll-Rand Company has developed a heavy-duty $2^1/_2$-inch vibrator called the 10V. It is suitable for average building construction, walls, floor and roof slabs, medium columns, and light foundation work, according to a report from the company. A $2^1/_2$-inch-diameter $17^3/_4$-inch-long vibrating head allows the tool to get between reinforcing bars easily. Over-all length of the tool equipped with a standard 5-foot hose assembly measures $84^7/_8$ inches. (Other 10-, 15-, and 20-foot hose assemblies are available as optional equipment.) With air furnished at 90-psig pressure, the 10V delivers 15,000 vibrations per minute at no load and 9000 vibrations per minute at full load. A $^1/_2$-inch pipe tap hose connection is provided and use of $^1/_2$-inch hose is recommended by the manufacturer. Form 5278 describes the tool and delineates its engineering features. *Ingersoll-Rand Company*, 11 Broadway, New York 4, N. Y.

ELECTRICALLY HEATED CO_2 manifolds prevent regulator freeze ups and at the same time cut gas consumption during welding operations. Different sizes are available for use on 2- and 4-bottle systems. Each is self-contained and is designed to work with any set of standard regulators. They come equipped with all the necessary fittings, gaskets and electrical wiring. Heating is accomplished by an electrical element built into the manifold. The smaller unit, designated WELCO AF-2, has two



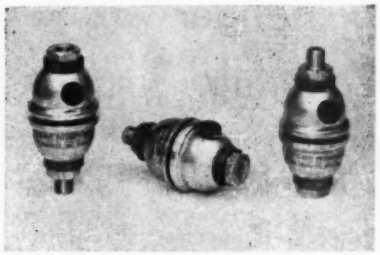
input gas ports and one outlet for connection to regulator valves and gauges. The AF-4 is the larger manifold. It has four input ports to facilitate higher volume welding production in shops and areas where built-in carbon-dioxide service is not available. Designed to eliminate cumbersome 3-part manifolds, the AF-2 and AF-4 are reportedly safe and simple to work. *World Electric Company*, 4614 Prospect Avenue, Cleveland 3, Ohio.

HOSE swivels, featuring steel ball bearing design, can be used on liquid lines in general industrial applications where easy swiveling action is necessary. The unit revolves freely at pressures to 125 psig and temperatures to 225° F, it is reported. The #20, as it is designated, can be used to make piping and tubing flexible or movable, or as a swivel connector on hose to eliminate dam.ge due to twisting. The ball bearing design enables the swivel to withstand severe radial and thrust forces. Available in $1^1/_4$- and $1^1/_2$-inch sizes, the #20 is made leakproof by Buna-N O-rings. Construction is of bronze and aluminum.



Ball bearing races are locked in by snap rings without hindering the swivel action. Features, illustrations, prices, specifications and complete engineering information are given in a 2-page bulletin —NP 20-E. *OPW-Jordan*, 6013 Wiehe Road, Cincinnati 13, Ohio.

INJECT-O-MIST pneumatic lubricators for intermittently operated air cylinders, motors, hand tools, etc., are now designed with aluminum end bells that overlap a short oil sight glass. It is said that this provides maximum strength and wear protection to the glass. The standard horizontal model, TAR250FM, is shown at the center of the illustration. Special

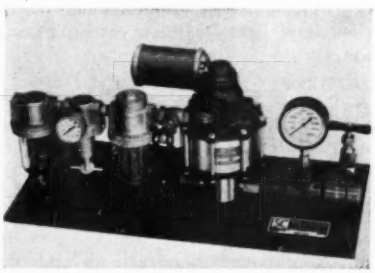


design models TVU and TVD for up or down air discharge, are shown at left and right. Inject-O-Mists are available with female inlet and male outlet brass adapters in $^1/_8$-, $^1/_4$- and $^3/_8$-inch pipe thread sizes. *Carlson Products, Inc.*, 5309 N. Twenty-fourth Street, Omaha 10, Neb.

ENGINEERS, technicians and executives concerned with the expanding volume of trade and interchange of technical information between the United States and Europe will find handy a 48-page handbook of reference tables for converting U. S. and British units into metric units (and vice versa). Of pocket size, it has conversion tables in the nine areas of temperature, volume, weight, liquid volume, pressure, heat units, and units of length, surface and production. For rapid conversions, the tables have stepped-down thumb indexes. The user can quickly locate a known value in any particular table and on the same horizontal line find the equivalent values in the other systems. In addition to the tables, five pages of the spiral-bound book are devoted to conversion factors for length, area, volume, dry volume, weights, specific weights, pressures and quantities. The cost is $2.56 in the U. S.: $2.75 elsewhere. *European Technical Coverage, Inc.*, 75 E. Wacker Drive, Chicago 1, Ill.

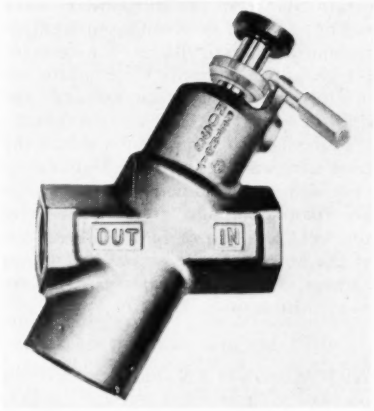
"Calm down. If there *is* a fire in the plant we have forms to fill out."

AIR-OPERATED, hydraulic power units with hydraulic pressures ranging from 500 to 30,000 psig are available in two series for oil and water service in operating hydraulic equipment and in static and burst pressure testing. These are the SC40-500 with ten models from 500- to 25,000-psig hydraulic pressure; and SC40-600 with eight models from 1000- to 30,000-psig hydraulic pressure. They provide a range of operating pressures and capacities: from 3 gpm at 500 psig, to 20 cubic inches per minute at 30,000 psig. Only 100-psig pressure is required for any model pump to attain its maximum performance curve at full-rated flow. Pumps in the units can't stall, according to a manufacturer's report, because of a built-in pilot valve that assures positive operation under all running conditions. All models in each series are compact, light in weight and easy to install with only three connections required—to air, fluid supply and to the work. Two pressure ports provide ease of control during operation.



The air piston actuating valve is automatically positioned on the power stroke with each cycle of operation. The valve assembly itself is precision-fitted to reduce the possibility of leakage and to assure smooth operation. *SC Hydraulic Engineering Corporation*, 14032 S. Avalon Boulevard, Los Angeles 61, Calif.

L-O-X (lock-out and exhaust) valves were designed to increase safety during repair, maintenance and shutdown periods on pneumatic machines. Segments of air circuits can be isolated and inactivated with them, making a portion of the machine more safely available for servicing, without interfering with other parts of the circuit. Installed in the air supply line leading to the machine, upstream of any operating valve, normally the air flow is right through the L-O-X. When it is shifted, air to the machine is shut off and the air downstream is exhausted to atmosphere. The valve can then be locked in the closed position with a padlock. If a closed-center valve is used in the circuit, compressed air can be trapped downstream of it. Additional lock-out and exhaust valves should be installed on each outlet port of the closed-center valve. The L-O-X has only one moving part, is locked in the open position and designed for a minimum pressure drop. It is made in four sizes for $^3/_8$- to 1-inch pipe. The area through the valve is greater than the interior of the standard pipe for which it is tapped. *Ross Operating Valve Company*, 120 E. Golden Gate Avenue, Detroit 3, Mich.



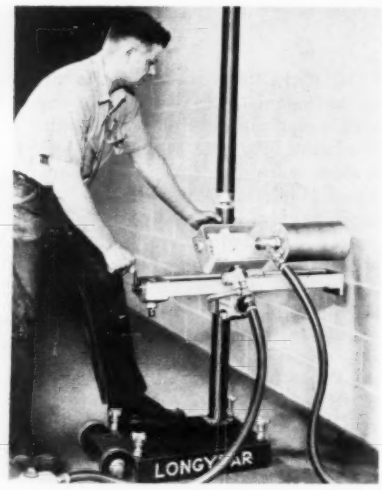
GLOVES, designed to reflect 90 percent of all radiant heat in work where high temperatures are involved, have leather palms and aluminized asbestos backs and thumbs that make them particularly suitable for welding and cutting operations, furnace work, or any other operation involving extreme radiant heat. The backs are a combination of asbestos and special heat resistant fabric called Scotch-Shield, developed by Minnesota Mining & Manufacturing Company. Airco is marketing the gloves in three styles: a 5-finger carpincho leather glove; a 1-finger mitten of green heat-resistant leather; and a 5-finger glove of heat-resistant leather. All three will have aluminized backs (excluding gauntlet) and thumbs. They are available either lined or unlined. *Air Reduction Company, Inc.*, Air Reduction Sales Company Division, 150 E. Forty-second Street, New York 17, N. Y.

FOR PRECISE timing and cycling of automated machinery or semiautomatic work functions with air or electricity, a Minimatic Sequence Programer (MSP-1) is ideal. According to the manufacturer's 2-page bulletin, No. 360, the unit is supplied with eight 1-piece phenolic cams in any combination of eight standard degrees of rotation cuts—or uncut for the buyer's own machining, or special-cut at a nominal cost—plus an Allen wrench for cam adjustment. Its mounting bracket accommodates eight Clippard cam followers and air valves, plus many types of small snap-action electrical switches. Individual cams are quickly adjusted with a single set screw in the hub, and the unit may be powered with any small geared-down motor developing 10 inch-pounds, or more, torque, or may be driven directly from the machine it is controlling. With proper valving, the unit can control large pilot-operated valves, or can be connected directly to air cylinders. *Clippard Instrument Laboratory*, 7390 Colerain Road, Cincinnati 39, Ohio.

TWO industrial diamond drills with optional, interchangeable air and electric drives, have been introduced by E. J. Longyear Company. The "330" is a swivel type of 6-inch capacity that drills holes at any angle through reinforced concrete, brick, tile or stone. It swivels in two directions, raises and lowers on a column attached to its base, or can be taken off its base and mounted on a column or horizontal crossbar. Model "305" is a lightweight vertical hole drill, also of 6-inch capacity. For horizontal drilling, the screw feed mechanism can be removed from the base and anchored to the wall. Air motors rated at 350–1500 rpm, 60 rpm, and 90-psig pressure, or electric motors rated at 350–1000 rpm, 110 v, can be used. The air-powered units were developed because of the great need for diamond drilling in refineries and chemical plants, and in

"Game almost over?"

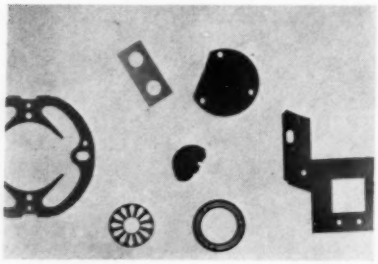
plants and on construction jobs where compressed air is the primary source of



tool power. The illustration shows a Model "330" equipped with an air motor. *E. J. Longyear Company*, 76 S. Eighth Street, Minneapolis 20, Minn.

RADIOACTIVE compounds have been cataloged in *Schedule F*, available from Nuclear-Chicago Corporation. The brochure lists more than 400 radiolabeled compounds, including dozens of new items, many of which are available in AEC license-exempt quantities. 223 carbon-14, 79 sulphur-35, 46 phosphorus-32, and 42 tritium labeled compounds are cataloged with prices and quantity discounts. High-intensity beta and gamma sources for thickness gauging, radiography, clinical therapy, and research projects are also described. Low-cost license-exempt radionuclide kits for student use and radioactivity standards are included. *Nuclear-Chicago Corporation*, 359 E. Howard Avenue at Nuclear Drive, Des Plaines, Ill.

PHOTO-MECHANICAL duplication is a process by which thin metal stampings, either in small or large lots, can be produced from any sheet material.

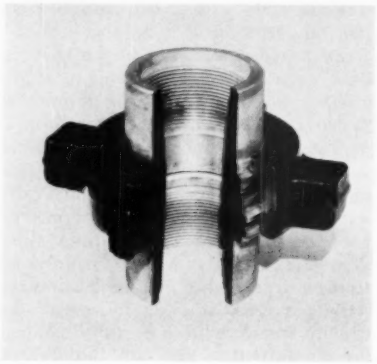


(Dayton Rogers, the developer, indicates that at present the limit is 0.005–0.015-inch stock thickness, with a maximum area of 20x20 inches.) The make-ready for the production of such parts sometimes runs as low as 5 percent of conventional tooling. There is no limit in the detail that can be introduced. The make-ready is so flexible that on reorders contour and detail changes can be made for about $4. Secondary operations can be introduced, such as forming and drawing; however, on all flat blanks, definite flatness is assured with no distortion whatsoever, with a high degree of accuracy at all times. The stampings are completely burr free. Samples of the work are shown in the illustration at the bottom of the preceding column. *Dayton Rogers Manufacturing Company*, Minneapolis 7, Minn.

LIQUID OXYGEN handlers will be pleased to hear of a special garment that can be worn on the job with safety. When the U. S. Marine Corps discovered last year that a Vinyl coated glass cloth used in aprons was impervious to liquid oxygen as well as being acid and abrasive resistant, M. Setlow & Son Inc., developed its garment of the same fabric. It offers complete coverage for the head and body. The suit opens down the back, and has a hood that can be slipped forward when not in use. Full details may be obtained from the company. *M. Setlow & Sons Inc.*, 131 Chestnut Street, New Haven, Conn.

CONSTRUCTION, optional accessories and complete specifications of Conoflow's Series LB control valve is given in Data Sheet No. 101. It describes the LB valve as a single-seated, split-body unit with a powerful pneumatic cylinder actuator and built-in positioner. Tight shutoff is guaranteed by the manufacturer, in all sizes—$^3/_4$ inch through 6 inches—regardless of the operating variables. Other features include a choice of flange connections for every requirement, a liftout seat ring, and piston lipseals that assure bubble-tight sealing. Requests for the 2-page sheet should be addressed to the manufacturer. *Conoflow Corporation*, 2100 Arch Street, Philadelphia 3, Pa.

UNIONS with a fast make-and-break feature that speeds and simplifies installation and maintenance of pipeline systems—as required by oil drillers, petroleum processors, chemical producers, and many food processors—have been developed for 4000- and 6000-psig working pressures. They have a full 3-pitch acme thread that turns easily, resists being clogged by foreign matter, and can be cleaned quickly. In addition to providing easier make-and-break, the acme thread withstands considerably more physical abuse than a conventional vee thread, according to officials of Clayton Mark. The 6000-psig-pressure unions have a combination seat, both rubber-to-metal and metal-to-metal, to assure long, trouble-free service life in high-pressure applications. The rubber seal is replaceable if it should wear or be affected by



products handled. The other union has a metal-to-metal seat only, and is not illustrated here. *Clayton Mark & Company*, 1900 Dempster Street, Evanston, Ill.

SPEEDCAT is a small crawler tractor with a hydraulically operated bucket that can replace hand unloading of foundry sand, salt, grain, chemicals, and other bulk material from box cars or other confined areas. The design gives it plenty of power to operate in and dig into any material, it is reported. Because of its small size—41 x 84 inches—the Speedcat Low Lift can be operated wherever space limitations prevent the use of large clumsy equipment. Loader models are also available. A free color circular describes these unique tractors. *Mead Specialties Company*, Tractor Division, TR-130, 4111 N. Knox Avenue, Chicago 41, Ill.

COMPRESSED AIR has its long list of useful applications, but like any other power medium, also has its dangers. One of these is the flyback of wood or metal chips, dust, or cuttings during the cleaning of machines, work tables and the like with pneumatic blow guns. Saf-T-Air is said to eliminate this hazard. It features a cyclonic whirling air action that, in conjunction with the central concentrated air stream, forces particles down and to the sides. In effect, this sets up a conical shield of high-velocity air between the particles and the operator, preventing flyback. Chips, dust and other waste won't rise more than 1 inch above the surface when the gun is properly used, according to a report from the manufacturer. Cleaning jobs can be done with a single pass because of the gun's multiple orifices, thereby sav-

ing time and costs. The pistol-grip unit is cast in one piece and although it is designed to operate on pressures

ranging from 30 to 100 psig, it has been successfully tested to a pressure of 200 psig. Each blow gun is complete with a $^1/_4$-inch female NPT air inlet and is guaranteed for a year. *E. V. Nielsen Inc.*, 575 Hope Street, Stamford, Conn.

Instruction . . .

Drilling and Blasting Symposia, sponsored by the mining departments of the University of Minnesota, Pennsylvania State University and the Colorado School of Mines, are held biannually. The next will be October 17-19 at Golden, Colo. The agenda includes papers that will be of interest both to the practical man in the field and to the academic individual. This is the third in a series of ten conclaves devoted specifically to production drilling and blasting. A committee that includes representatives of the three sponsoring institutions as well as a number from industry is working out the details. Further information may be obtained by writing to the chairman of the Organizing Committee, Drilling and Blasting Symposium, Colorado School of Mines, Department of Mining Engineering, Golden, Colo.

Films . . .

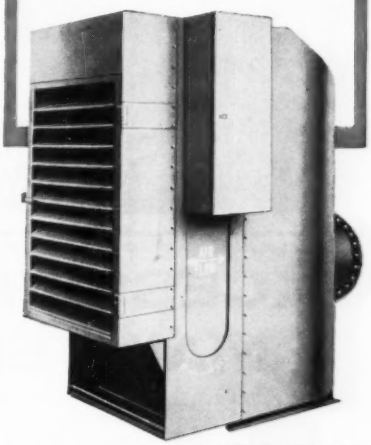
Millions On The Move, a 16-mm, sound-and-color film about America's traffic congestion problem is available on a free-loan basis to community groups located within a 75-mile radius of cities with a population of 75,000 or more. It asks the question: Will you continue to pay the high price of traffic congestion, or will you live modernly with coordinated public transportation? The price we pay is high, costing Americans billions of dollars annually in depreciating business and real estate values, lost man-hours and immeasurable personal costs and discomforts. The key to removing the horn-honking traffic, as this film points out, is the movement of people—not vehicles. Several dramatic examples show rapid transit vehicles, out-lying parking areas, and modernized rail and bus facilities. The movie is presented by General Electric Company and was produced by Wilding, Inc. Prints may be obtained from Association Films' distribution centers located at: Broad and Elm Streets, Ridgefield, N. J.; 561 Hillgrove Avenue, La Grange, Ill.; 1108 Jackson Street, Dallas, Tex., and 799 Stevenson Street, San Francisco, Calif.

Ideal Transport Story is about the world's longest—$5^1/_2$ miles—permanent transport belt conveyor system. The 16-mm, sound-and-color, 22-minute motion picture shows all phases of construction of the unique conveyor system from survey and site clearance through operation, including some interesting aerial shots. The all-weather conveyor winds through the Oklahoma countryside in the shape of a giant letter "S" carrying limestone and shale at a rate of 1000 tons an hour from Ideal Cement Company's quarry in Lawrence to its plant in Ada. This is the first major conveyor installation supported by prestressed concrete structures and is made up of seven separate belt conveyors, arranged to feed onto each other consecutively. One conveyor, almost $2^1/_4$ miles in length, is the longest single-flight ever built and required a belt $4^1/_2$ miles long. The conveyor system crosses two highways and the Frisco and Santa Fe railroads. It was designed and furnished by Link-Belt under a turnkey contract. Requests to borrow the film on a free-loan basis can be sent on company letterhead, to Link-Belt Company, Department PR, Prudential Plaza, Chicago 1, Ill.

50,000 Lives is a dramatic film about the newly approved mouth-to-mouth rescue breath technique. This $13^1/_2$-minute, color-and-sound film demonstrates both the mouth-to-mouth and the

". . . what do you mean, 'How did I know the order was short 18 pieces?' "

AAF
Multi-Duty
Filters
Assure
Clean Intake
Air
Automatically



Type CMS Multi-Duty for air volumes of 3000 CFM and up.

When your engines and compressors are protected by AAF Multi-Duty Self-Cleaning Filters, you *know* that intake air is *clean.*

Uniform air delivery, constant efficiency, low operating resistance and infrequent maintenance are "musts" for true dust protection. Multi-Duty measures up on every count because this filter keeps itself "fit" through continuous self-cleaning action.

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Rarely will you find an item of industrial, construction or road building equipment that won't run best and cheapest on Continental Red Seal power. The reason lies in specialization—in Continental's long-standing policy of engineering each model precisely to the work to be done. Whatever the machine . . . whatever its job . . . you can bank on it for abundant power at the speeds consistent with low fuel and upkeep cost.

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EXCESSIVE AIR TOOL MAINTENANCE?

The majority of air tool down time and maintenance cost can be traced directly to dirty compressed air. Rust, pipe scale and other foreign materials are picked up from the air system by the moving air stream. This entrained debris is a sure source of trouble if allowed to enter your air operated equipment.

An Adams Poro-Stone filter is scientifically designed for maximum separating efficiency. Centrifugal forces trap entrained solids and liquids in the exclusive interior shell slots. They then drain into the lower liquid chamber for periodic removal. The gas then is completely cleaned as it diffuses thru the minute voids of the Poro-Stone element.

Throughout their operating range, they require only ½ PSI pressure drop—a negligible reduction from line pressure. Virtually no maintenance or servicing is required—assuring continued cost cutting, trouble free air.

Adams Poro-Stone air filters are available from stock in a wide range of sizes. Find out today how they can eliminate your compressed air problems. Write for Bulletin 117.

R. P. ADAMS CO., INC.

209 East Park Drive • Buffalo 17, New York

mouth-to-airway techniques of resuscitation, and shows why these methods are far superior to previously used manual methods. Mentioned in the *Bible* but overlooked until recently, the technique is now the official life-saving method adopted by the American Red Cross and the armed forces of the United States. It is reported that it can save 50,000 lives needlessly lost each year through asphyxiation. Underwritten by Johnson & Johnson and produced by M P O as an educational public service program, the film is aimed at as many viewers as possible to teach them the simple rescue techniques. Prints may be obtained on a free-loan basis from Association Films, Inc., distribution centers located in the following cities: Broad at Elm streets, Ridgefield, N. J.; 561 Hillgrove Avenue, La Grange, Ill.; 799 Stevenson Street, San Francisco, Calif.; and 1108 Jackson Street, Dallas, Tex.

Books . . .

Problems of Low Temperature Physics and Thermodynamics (published by Pergamon Press, Inc., 122 E. Fifty-fifth Street, New York 22, N. Y.; 4 & 5 Fitzroy Square, London W. 1, England; 24 Rue des Ecoles, Paris V, France; or Am Salzhaus 4, Frankfurt, Germany) consists of the proceedings of the meeting of Commission I of the International Institute of Refrigeration at the University of Delft, The Netherlands, in 1958. One hundred eighty scientists from fourteen countries conferred, presenting 48 papers. The general subjects covered include cryogenic apparatus; thermometry, the disturbed crystal lattice, and transport phenomena in liquids and gases. The volume is profusely illustrated with charts, graphs and illustrations, and each paper is followed by bibliographical references. 344 pages. Cost $11.50.

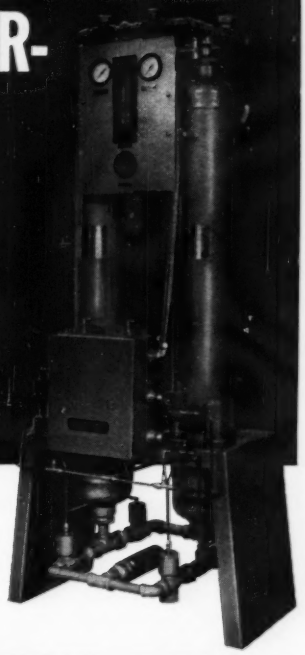
Rock Drill Data (published by Compressed Air Magazine Company, 942 Memorial Parkway, Phillipsburg, N. J.) is designed for mining and construction engineers and others concerned with drilling rock who need a compendium of information at their fingertips. The book was written by the late E. H. Dickenson, a rock drilling expert for Ingersoll-Rand Company who spent a lifetime studying drilling methods throughout the world and putting on paper what he learned. Ted Slager, Jr., mining engineer and rock drill publications specialist for I-R, put it in final form. It is broad in scope but presented in a concise, easy-to-read manner. Reviewed at publication by the editors of the nation's foremost mining and construction magazines, the volume is rated the "first really useful" collection of its

type to be published. Divided into 41 chapters, the work begins with a brief history of the rock drill, tracing its development from J. J. Couch's cantankerous, steam-driven behemoth of 1849 to the efficient efforts of today's drill engineers and metallurgists. Next, comes a brief classification of rock, a word about hole spacing and explosives, two chapters that classify drills and explain part names, and a succinct chapter that tells the reader how a drill works.

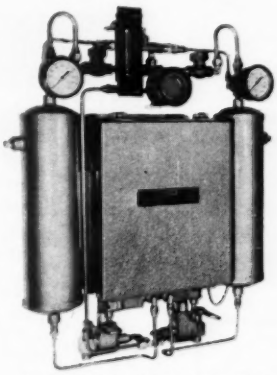
Then the book gets down to the business of mining, tunneling, excavation, demolition, and quarrying. Procedures are given for using Jackhamers, Jackdrills, stoppers, paving breakers and rock bolting equipment. Moving to larger machines, the volume explains the proper use of wagon drills, crawler-mounted drills and big rigs such as the Crawlmaster, Drillmaster and Quarrymaster. Line-hole work, drilling and broaching, and submarine drilling have their own chapters. There is another section about calyx and wiresaw drills, another about tugger hoists. Detailed chapters go into long-hole drilling, practices in high-speed tunneling and the types of tunnel ventilation. The book then proceeds to the problem of drill maintenance. The reader is told how to properly select and estimate the bits and rods needed for a job. Drill steel is covered in a separate chapter as is the shop for properly maintaining bits, steels and drills. Complexities of rod making and bit regrinding are explained, followed by data on drill upkeep, air requirements, and lubrication during drilling. The last few chapters deal with: troubles commonly encountered in drill operation; nonstandard drill mountings—chiefly jumbos; and dust and fog produced in drilling. Personnel who work outside the U. S. will find useful a chapter that lists rock drill terms as they are known in Brazil, France, Mexico and Peru. The final chapter contains 39 tables valuable to the driller in the field, ranging from logarithms to a table giving dollars wasted per month by a 1/32-inch air leak. An excellent index, listing page numbers for 239 subjects, ends the publication. Hardbound black leatherette, 399 pages. Cost, $3.

LOW COST, DEPENDABLE INSTRUMENT AIR-

TRINITY Heat-Les



Increase dependability and accuracy of measurement and control in your system by specifying a dependable Trinity Heat-Les Dryer. These amazing dryers, operating on a principle so simple, yet so efficient, are establishing unparalleled operating records in over a thousand installations.

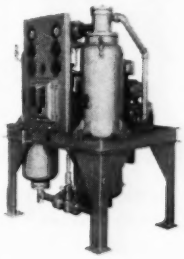


Trinity Heat-Les Dryers are available in standard models ranging from 2 SCFM to 5000 SCFM. Units up to 200 SCFM are available from stock.

★ Low initial cost
★ Completely eliminates costly electric or steam heaters
★ No increase in effluent gas temperature
★ Low installation costs
★ Low operating and maintenance costs
★ Built-in safety system provides dry air for extended period after power failure.

ALSO HEAT-REACTIVATED DRYERS

Trinity also offers a complete range of capacities in heat-reactivated type dryers of an advanced design, offering the greatest economies and performance for this type dryer... **WRITE FOR COMPLETE TRINITY DRYER AND ACCESSORY TECHNICAL MANUALS...**



TRINITY World leader in dry gas/air systems

Heat-Les Dryers • Heat-reactivated Dryers
Thermocouples and Thermowells

TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

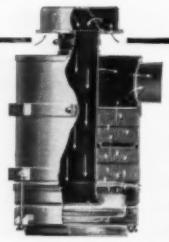
Great names—that made scientific filtration possible!

Bernoulli's Principle: "The pressure of a fluid, either liquid or gas, decreases as velocity increases and increases as velocity decreases."
Daniel Bernoulli (1700-1782)

For more than 35 years, Air-Maze has specialized in the filtration of liquids and gases. And although Bernoulli lived more than 200 years ago, our engineers must take into account his discoveries in designing and developing new products for industry.

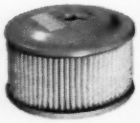
From crawler tractors to jet aircraft . . . from gear cases to modern air-conditioned buildings, Air-Maze filters are keeping equipment running better and longer by keeping it clean and free from damaging contaminants.

Shown below are representative products developed by Air-Maze engineers to solve specialized filtration problems. If your product involve any gas or liquid that moves, Air-Maze can help you.



Air-Maze Oil Bath stack type air filters combine air intake protection with low pressure loss and longer intervals between servicing.

Only Air-Maze Dry Type air filters have the exclusive Dry-Maze washable, non-paper element. Lasts indefinitely.



OTHER AIR-MAZE PRODUCTS: Air Filters • Liquid Filters Intake Silencers • Exhaust Spark Arresters • Breather Filters Oil Mist Eliminators

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For high quality production and one source responsibility, for the complete job call National Forge — specialists for over forty years in commercial forgings.

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Here is the pair for clean, dry air . .

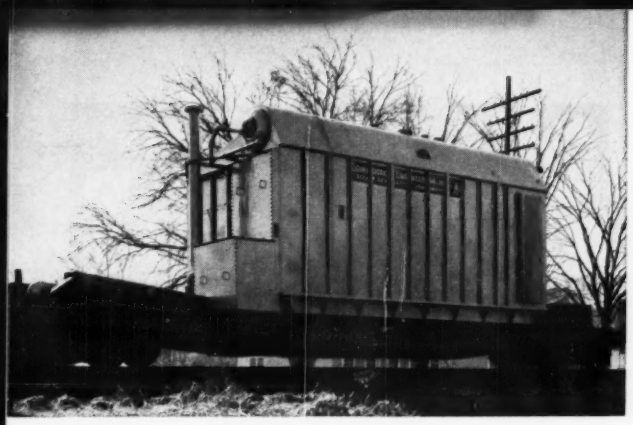
JOHNSON AFTERCOOLER
Used where moisture is vaporized by the heat of compression. Circulates cooling water around the line, condenses the oil and water vapor so Separator can remove them. Simple in design, highly efficient in performance.

SIZES FOR ALL NEEDS

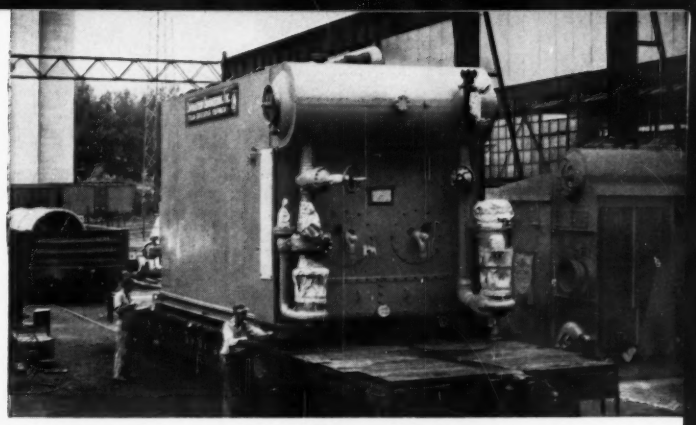
JOHNSON SEPARATOR
Removes more than 99% of all water, dirt and oil from compressed air or steam. Combines the *two* best principles of separation—first allows air to expand slightly, then changes flow direction with the "Thousand Baffles". Model illustrated is the newest idea in separator design, with self-draining trap mechanism built right in.

WRITE FOR BULLETIN

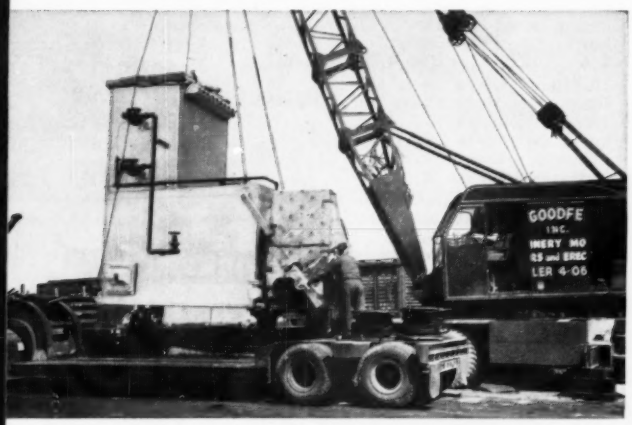
The Johnson Corporation
830 Wood Street • Three Rivers, Mich.



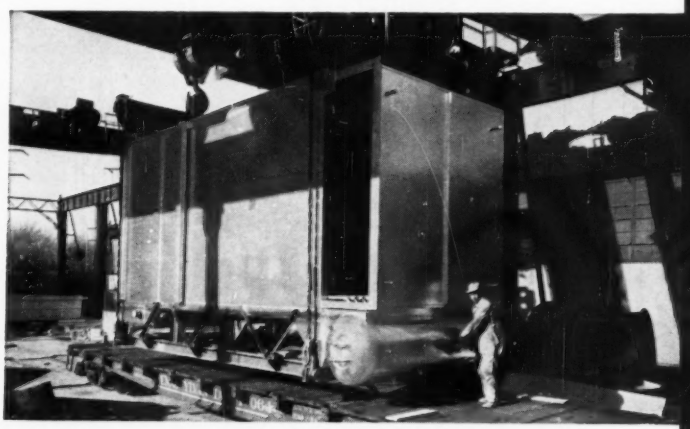
To 90,000 lb/hr . . . Type VP—A compact, economical, natural circulation, *package* boiler for the majority of industrial requirements. Steam capacities from 4,000 to 90,000 lb/hr; pressures to 700 psi; temperatures to 750 F. Most sizes shipped complete with firing equipment for oil or gas, setting and forced draft fan arrangement.



To 120,000 lb/hr . . . Type PCC—Shop-assembled *controlled circulation* boiler providing high output and high temperatures in a compact, high-performance unit. Capacities—80,000 to 120,000 lb/hr; pressures to 1,000 psi; temperatures to 900 F. Designed for minimum installation, operation and maintenance costs.



To 50,000,000 Btu/hr . . . Type HCC—High-temperature water boiler, shop-assembled, widely used for large-scale, economical heating of commercial and industrial installations—including many military air bases. Controlled circulation, pressurized oil or gas-fired from 10 to 50 million Btu; coal-fired to 40 million Btu. Field-assembled units to 300 million Btu.



To 50,000 lb/hr . . . Type WCC—Shop-assembled. Utilizes waste heat from open hearths or chemical processes. C-E controlled circulation design obtains big boiler performance from space-saving units. Capacities to 50,000 lb/hr—and up, depending on waste heat conditions—with pressures to 450 psi and temperatures to 750 F. Capacities of field-assembled units are virtually unlimited.

shop assembled to 120,000 lb/hr capacity

Designed for Industry by UTILITY-BOILER ENGINEERS

C-E shop-assembled boilers are available for a wide range of industrial, commercial and institutional applications. They are produced by the same C-E engineers who design the world's biggest and most efficient utility boilers—with capacities to 4,000,000 lb/hr and pressures to 5,000 psi. For the most economical solution to *your* steam or high-temperature water problems, write to C-E, outlining your requirements. ***Catalogs are available.***

COMBUSTION ENGINEERING

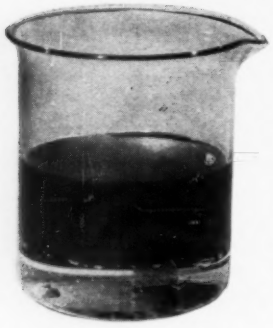
C-E

Combustion Engineering Building,
200 Madison Avenue, New York 16, N. Y.
CANADA: COMBUSTION ENGINEERING-SUPERHEATER LTD.

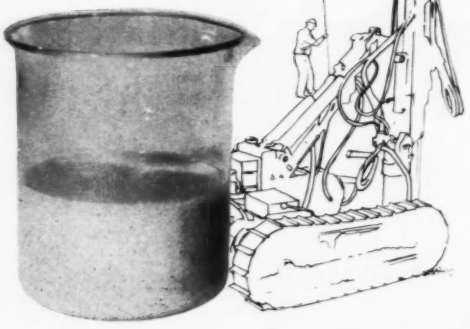
C-277-A

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

WHAT YOU SHOULD KNOW ABOUT AIR TOOL UPKEEP



Ordinary oil separates from water



NON-FLUID OIL TRADE MARK REGISTERED

is compatible with water

Until the introduction of NR Grades of NON-FLUID OIL, users of all types of pneumatic powered units have fought a losing battle with the moisture content of all compressed air. No regular oil worked with this moisture; it was a constant fight with power and efficiency on the losing side.

NR Grades work on the logical principle, "if you can't lick, it join it." Our specially designed and engineered grades for pneumatic service form a permanent emulsion with this airborne moisture, thus eliminating the normally accepted sticking, gumming and rusting. That's why pneumatic tool manufacturers use and recommend the NR Grades of NON-FLUID OIL for their tools.

Write for Free Testing Sample and Bulletin No. 550.

NEW YORK & NEW JERSEY LUBRICANT COMPANY

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Also represented in principal industrial centers, including Pittsburgh, Pa., Cleveland and Cincinnati, Ohio

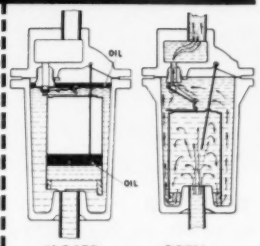
NON-FLUID OIL is not the name of a general class of lubricants, but is a specific product of our manufacture. So-called grease imitations of NON-FLUID OIL often prove dangerous and costly to use.

OIL WON'T STOP UP THIS AIR TRAP

Oil from heavy-duty compressors clogs ordinary ball-float traps—but not an Armstrong inverted bucket trap. The diagram at right shows how it handles even heavy oil.

(Warning—even an Armstrong will not handle oil-water emulsions described as "warm peanut butter".)

- **Handles Dirt**—No dead spots for dirt to collect. Dirt stays in suspension, won't settle on valve or seat—they're at top of trap.
- **Trouble-Free Construction**—Stainless steel working parts; heat-treated chrome steel valve and seat, lapped to a precision fit.
- **Flexible Installation** Installs above or below unit being drained, because of air bleed. Slight air loss (7-10 cu. ft./hr.) costs only about a penny a day, figuring air at 6¢ per 1000 cu. ft.
- **Low Cost, High Capacity**—On a size for size basis.



CLOSED OPEN

How It Works

CLOSED: Oil collects on top of water in trap. Air in trap floats bucket. Valve held closed by pressure.

OPEN: When water displaces air in bucket, bucket sinks, pulls on lever and opens valve. Oil floats out along with condensate.

SEND FOR BULLETIN

Bulletin No. 2024 shows how to select air traps for any job. Also gives complete data on all Armstrong air traps. For a copy, call your local Armstrong Representative, or write:

ARMSTRONG MACHINE WORKS

8854 Maple Street, Three Rivers, Michigan

TWO HANDY REFERENCE BOOKS

for

The Engineer, The Superintendent, The Operating Man

CAMERON PUMP OPERATORS' DATA:
Contains practical information covering the installation, operation and maintenance of centrifugal pumps.

CAMERON HYDRAULIC DATA:
Covers data useful in work involving the handling of liquids, steam, and water vapors.

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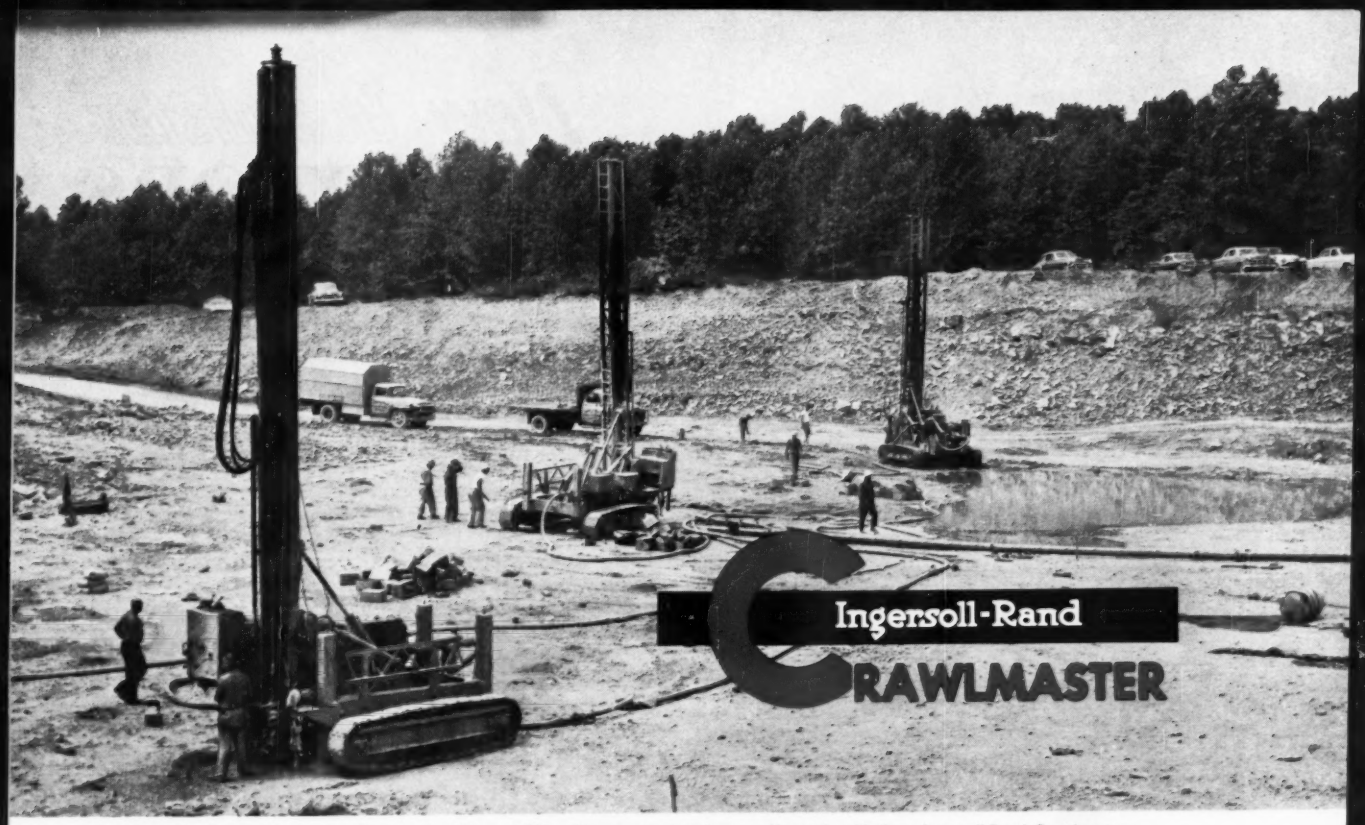

E. J. Petrillo's Yonkers Contracting Co. speeds drilling of 3½ million yard cut at Jugtown Mountain with three Ingersoll-Rand Crawlmasters.

new **SUPER-POWER** crawler drills help move Jugtown Mountain

In one of the largest highway road cuts east of the Mississippi, a 3½ million cubic yard "bite" is being taken out of Jugtown Mountain near Phillipsburg, N. J. The 117-ft deep cut requires removal of a million and a half cubic yards of granite gneiss—and the heavy drilling is being done by three of Ingersoll-Rand's new hydraulic-feed Crawlmaster drills.

Purchased for this job after competitive tests, the Crawlmasters are putting down 4½" holes 18 to 20 ft deep spaced on a 9 x 10 ft grid. Using the new D-525 drifter with 5¼" bore, they easily out-drilled two 5½" bore machines and are heavier and more ruggedly built throughout. Outstanding features include constant-pressure hydraulic feed and retraction, throttle-controlled reverse rotation, hydraulic tower positioning from vertical to horizontal, rugged tractor-type crawlers with enclosed gear drive from two 11½-hp air motors, and four 30" stroke hydraulic leveling jacks. Capable of percussion, rotary or Downhole drilling of 4" to 6½" holes at any angle, the Crawlmaster is the most rugged and versatile machine of its type ever developed.

Supplementary drilling on steep slopes is done by six Crawl-IR drills and all air for the project is provided by one 900-cfm and six 600-cfm Gyro-Flo portable compressors.

Ask your Ingersoll-Rand engineer for the complete Crawlmaster story—or send for Bulletin 4211.

One of the Crawlmasters makes short work of angle-drilling a larger boulder.

Ingersoll-Rand
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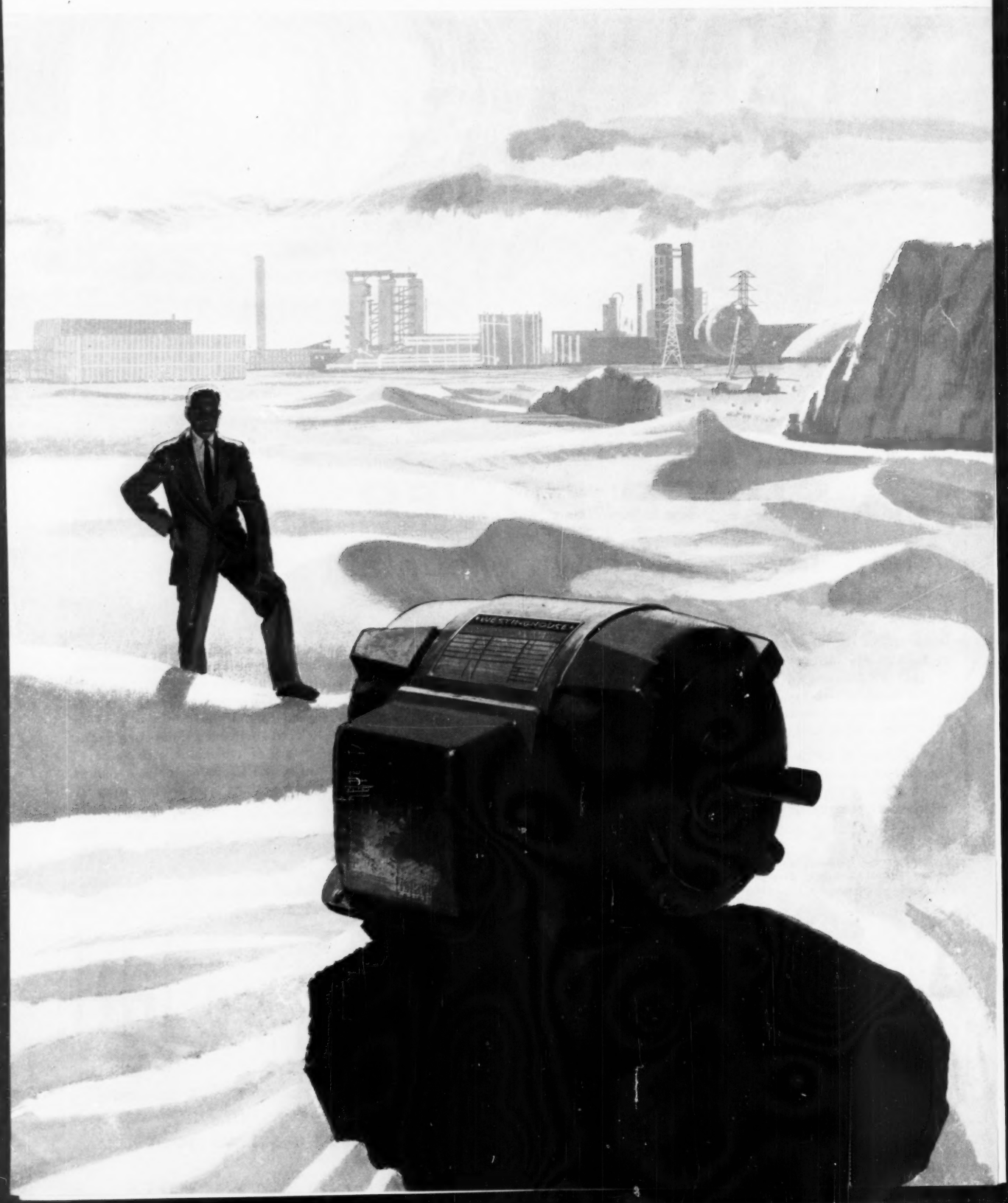
A CONSTANT STANDARD OF QUALITY IN EVERYTHING YOU NEED FOR DRILLING ROCK

New *Guardistor*

THE MAN & THE MOTORS



FROM WESTINGHOUSE

Guardistor motors let you match the full capability of the motor to the job— with complete safety—absolute confidence

Our Marketing Manager says:

- "You can match the motor to the load . . . use all the motor you are paying for.
- Provides positive protection based on winding temperature . . . *not* load current and/or power supply fluctuations.
- Eliminates time and expense of changing winter-summer heaters. No nuisance tripping, it's fail-safe . . ."

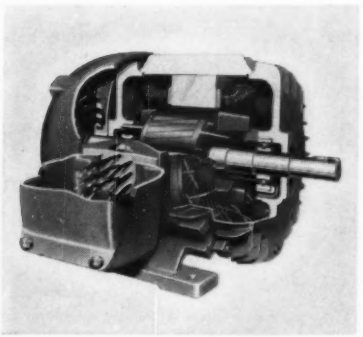
Our Engineering Manager says:

"With the breakthrough development of the Westinghouse Positive Temperature Coefficient thermistors, for the first time we can provide inherent protection against motor failure caused by excessive heat. The solid-state thermistors buried in the windings instantly sense excessive heat from any cause and simultaneously warn of trouble or automatically take the motor off the line. Thus, motor protection is placed where only true motor protection can be . . . in the windings."

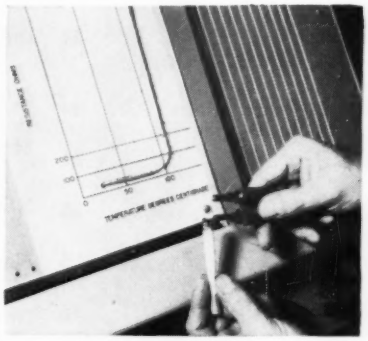
Call your Mr. Westinghouse for the application of a Guardistor* motor to your drive requirements . . . write for *Questions and Answers About . . . Guardistor* (B-7876). Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

*Trade-Mark

J-22160



Unlike remotely located sensing devices, PTC thermistors are buried in the windings of the Guardistor motor, instantly equating all temperature factors.



Ever alert PTC thermistors constantly totalize temperature, statically triggering an action *only* if critical temperature is reached.

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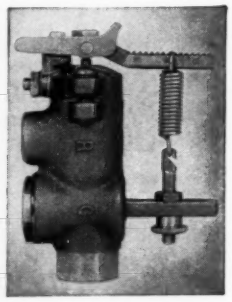
YOU CAN BE SURE...IF IT'S

Westinghouse

24 HOUR SERVICE

Factory Rebuilt

UNLOADER VALVES



any age

any make

any condition

One day is all it takes to change old, worn-out unloader valves into factory rebuilts with new valve guarantee. Conrader exchanges all makes. Cost 1/3 less than new valves.

HOW'S YOUR STOCK OF SPARE VALVES?

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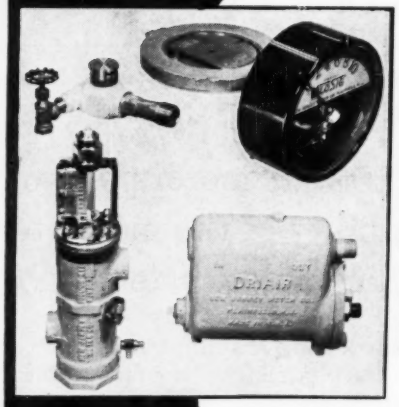

FLOW CONTROL
Air or Liquid
CONTROLLED BEST
with New Jersey METER UNITS

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- FLO-SIG INDICATORS
- DriAir SEPARATORS
- BLOWERS

Flow control problems stop being problems when you specify New Jersey Meter Units. Air Meters, the only pulsation compensated units available; Dri-Air Separators to remove water, oil, rust, scale and sediment from lines; Flo Sig Electric Signal Flow Indicators that report trouble before it happens; and Blowers especially adapted for furnaces and many modern applications.

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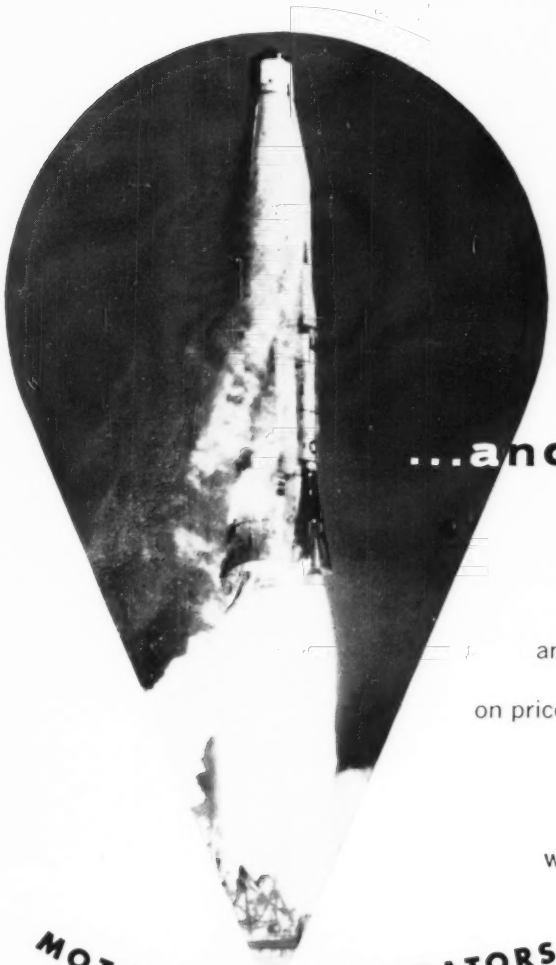

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...and the mighty ATLAS!

The 40,000 integral parts of the world famous ICBM Atlas are monitored by Precise Power Supply Systems designed and manufactured by ME*. The selection of ME* over competitive companies was made, not on price, but on the thorough and exacting technical proposal submitted by ME* "Injun-eers". Our pride in this project is natural. Of more importance to you should be the "rolled sleeves" attitude and enviable "know-how" with which we face each challenging problem.

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Your next project should include Marathon Electric specifications. Let us prove what ME* Can Do . . . for you!

This data and specification file on Marathon Electric Motors and Generators is now available for your ready reference use. May we mail you your free copy now?

* Marathon ELECTRIC

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Factories at Erie, Pa., and Earlville, Illinois

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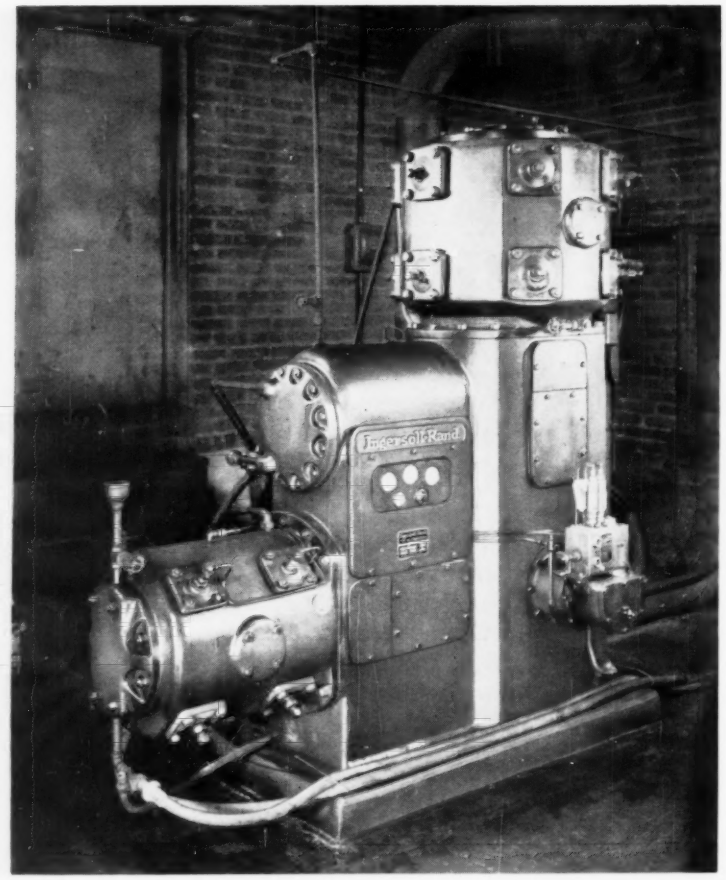

IN I-R COMPRESSORS,
TIME TELLS
THE DIFFERENCE

This XLE compressor has operated 24 hours a day for more than

63,648 HOURS

with no forced maintenance since installed in 1951

At the Conshohocken (Pa.) plant of the Lee Rubber & Tire Corporation, this Ingersoll-Rand XLE air compressor has operated at full load, 24 hours a day, six days a week, with no forced shutdowns since installed in 1951. At this writing, the unit has totalled 63,648 hours and is still going strong!

The only maintenance has been to check the valves once every three months on Sunday. This XLE operates as the plant's base-load air compressor, with the load variations being handled by another unit.

The XLE compressor had been purchased largely because of good performance of other I-R equipment in the same plant, including three different types of compressors and a variety of pumps.

The *extra value* that's built into every Ingersoll-Rand compressor pays off with *long-run economy*. Reduced maintenance and attention, over many years, mean long-range savings in the cost of air power. Ask your I-R representative to show you how to get your maximum *"Dividend on Payroll Dollars"* with a Planned Annual Review of your air power system.

***ONLY IR COMPRESSORS HAVE CHANNEL VALVES**

Known for high efficiency, quiet operation and exceptional durability. Entirely different. Each valve is a combination of rigid stainless-steel channels and bowed leaf springs, with trapped-air spaces which cushion action, prevent impact.

Ingersoll-Rand

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THE WORLD'S MOST COMPREHENSIVE COMPRESSOR EXPERIENCE